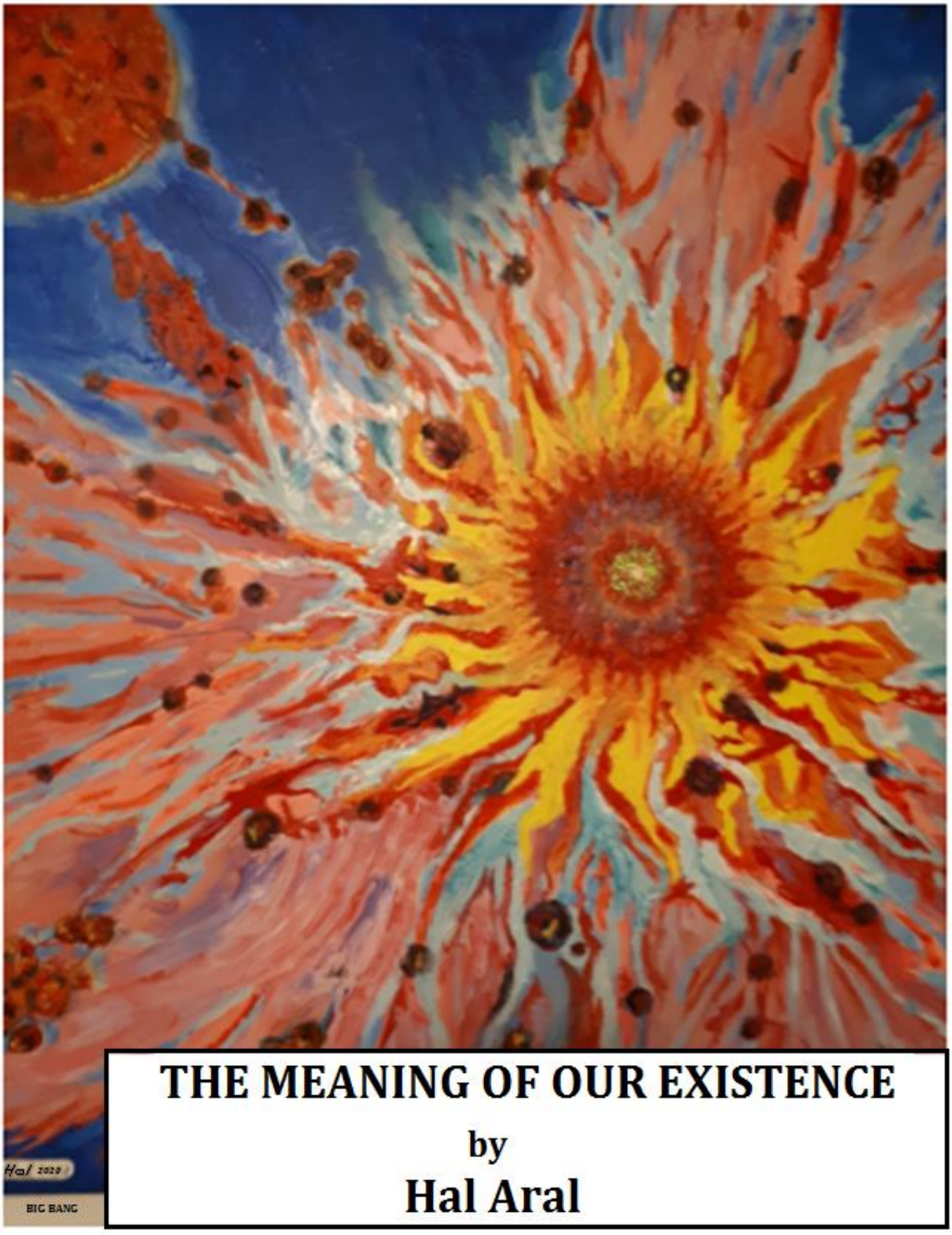

THE MEANING OF OUR EXISTENCE

by

Hal Aral

The Meaning Of Our Existence

(A NEW PERSPECTIVE ON THE ORIGIN OF OUR UNIVERSE AND OUR EXISTENCE)

by Hal Aral, PhD

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Author: I am Hal Aral, with a PhD from the University of Utrecht in the Netherlands. I am a research scientist, retired from the Commonwealth Scientific and Industrial Research Organisation in Australia, and also used to be an adjunct associate professor at Victoria University in Melbourne. As an earth scientist, I have a passion for making natural sciences and scientific knowledge relatable to everyone. This urge stems from the fact that, in the 21st century, 85% of humanity still believes in one form or another of supernatural power as the creator of everything - the stars, the moons, and us. The religious beliefs have been entrenched in human society for thousands of years through rituals and customs ingrained in our minds since childhood. In contrast, the spread of science, which defends Nature as the creator of everything - including us - based on facts, figures, and proven evidence, has often been left to scientists - whose language is often convoluted and confusing - making it difficult for even the average university graduate to comprehend. I hope that this book, written in simple and understandable language and covering diverse aspects of science, will help every inquisitive person find the meaning of the existence of the universe and its creations.

The Meaning of Our Existence

A NEW PERSPECTIVE ON THE ORIGIN OF OUR UNIVERSE AND OUR EXISTENCE –

"This book is dedicated to those who appreciate the glass is half full rather than half empty" Author

PREFACE

The Meaning of Our Existence presents an alternative perspective on the origin of the universe, challenging the conventional notion that everything came from nothing. This notion is similar to *creatio ex nihilo,* a theistic view that claims everything was created out of nothing by some divine creative act. In this book, we argue that what is considered as "nothing" is actually "something" known as the Substrate. The book explains that the universe emerged from this Substrate through processes somewhat similar to cosmic inflation and the Big Bang, proposing a more concise understanding of existence.

This book views dark energy and dark matter as the same, and are made up of repelling quanta with mass many orders of magnitude smaller than any known subatomic particle. In this book, we defend the premise that "dark" means repelling or negative mass - the opposite of attracting or positive mass. These two components make up the Substrate.

Negative masses exert a weak push against each other, but not strongly enough to result in an accelerating expansion of the universe. For the negative masses to push against each other, an external force must be applied. The acceleration of a repelling mass is in the direction of the applied force. We explain it is the centrifugal force applied to the repelling mass that prevents the stars at the outskirts of galaxies from flying away.

We claim that the universe was nucleated when a sector of the Substrate, at its absolute true vacuum state, decayed to form a local false vacuum. This process initiated the conversion of enormous amounts of potential energy into kinetic energy, leading to the ongoing expansion of the universe. If some of the released kinetic energy were not converted back into potential energy in the form of gas, dust, stars, galaxies, planets, and moons - what we refer to in this book as "potential energy storage silos" - the universe would have ended as quickly as it started.

We put forward the idea that our universe is in a metastable, false vacuum state or in motion like a cannonball rolling down a hillside toward the absolute true vacuum state - the universal ground

state. In the absence of enough of such silos rolling down the hill (converting potential energy to kinetic energy), the decay is not stopped but only slowed down.

We suggested that the universe expands increasingly faster, based on a known fact that when you roll a cannonball down a gentle hillside, the ball gains speed as the ball's potential energy converts into kinetic energy, which is the energy of motion. The lower the ball is, the less potential energy it has. As the potential energy of the ball decreases, the ball's speed increases. In this book we will explore how this analogy applies to our understanding of the accelerated expansion of the universe.

We claim that all the recycling protocols and energy minimization schemes of the universe that we know of, are there to delay the universe's descent to the bottom of the hills: the valley, the universal ground state, the freezing cold, vibrationless, motionless, timeless, dark space from which it originated.

We assert that we, like every other living being, are another form of the recycling protocol of our universe. We exist to delay the universe's descent to true vacuum state. Non-living matter does the same; it recycles repeatedly. Stars formed after the Big Bang *live* until they burn out their hydrogen, then collapse and explode to form gas and dust, only to collapse again to form new stars.

In this book, we repeatedly state that everything, both animate and inanimate, is made from vibrating atoms. We argue that the motivation behind the survival instincts of living beings comes from the atoms themselves, rather than from the living (selfish, immortal) genes. This is as if atoms were *aware* that their *immortality* would end if they stopped vibrating. They would revert to the universal ground state - the cold, vibrationless, motionless, timeless, dark space, the substrate from which they originated.

We said human beings are one of the greatest achievements of the universe we live in. Indeed, if we did not exist, who would know that the universe has ever existed? If intelligent beings did not exist, the universe would be nothing but a bunch of entangled clumps of atoms, lifelessly vibrating clusters of molecules, stars, galaxies, and planets. Then we asked: Have we evolved just to witness and admire what the universe has created? Could this be the purpose of our existence?

In this book, we express our admiration for how everything around us is amazingly, sophisticatedly, and purposefully designed to function in such a way that we inevitably ask whether there is an intelligent designer and a talented builder behind it all. We question whether the universe knows what it is doing and whether there is a puppet master, an architect, and a builder behind the existence of everything. We explain that what appears to be intelligent, intricate, and amazing designs and constructions does not emanate from a conscious body or mind or from a physical or spiritual

entity. The universe is not a living thing; it does not have the sophisticated cognitive abilities of humans. And we explained how.

In brief, this book integrates the existence of every living and non-living thing into one single purpose: to keep the universe existing and delay its reversion back to the universal ground state, which is the Substrate from which everything originated.

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This book often refers to the ideas, hypotheses and theories of others - scientists, theoreticians, theologians and philosophers. I tried to give credit to them all in the footnotes but I apologise if I missed to acknowledge the work of any other person; it was unintentional.

CHAPTER I. INTRODUCTION

"We are driven by our curiosity to learn more about what we are made up of" Raju Venugopalan

This book tries to find answers to questions like "*what is the purpose behind our existence?", and "why do we and everything else exist?"* How did we come into existence? What makes us alive? Who makes us alive? What are those things filling the night sky? Where did they all come from? Why do they exist? Who created the universe? Is there a designer or a builder for all the amazingly intricate, most sophisticated living and nonliving things around us?

In this book, we wanted to find out if there is a puppet-master, a creator of everything. We asked many *how* and *why* questions. We wanted ultimately to solve the mystery surrounding the meaning of our existence.

Before we proceed, we should note that this book is not about the meaning of our daily lives. We are not here to talk about meaning in life, or a meaningful life, or to suggest recipes on how to make your life more meaningful. Evidently, each human creates meaning in his or her own life. Rather, we are here to trace our existence back to the origins of life on Earth, and the birth of the universe.

We have been told since our childhood, the God of Christianity is the creator of everything and we humans are the most special living beings created by God. The Holy book declared us special, supreme beings to rule over every other living being. Are we really as special as declared by the Bible? Why should we be so special while we are so insignificant within this vast universe? The Earth we live on orbits an undistinguished star called the Sun somewhere far out in an arm of a spiral galaxy called Milky Way, the home for billions of other stars. And our galaxy is only one of billions of other galaxies distributed throughout the vastness of the universe. So, why should we be so special to rule over every other creature on Earth?

Humans wonder if there are other planets with living beings in this universe. If there are; do they also believe a God created them? Is their god different or the same God of ours? Do they also believe some supernatural entity created the cosmos and everything in it in six days? Is there really one intelligent designer behind every creation in this vast universe?

The fact is although countless thinking brains have spent thousands of years putting forth ideas, hypotheses, and theories, and many versions of supernatural powers and deities - so far they have

struggled to come up with a coherent explanation of the meaning of our existence - how and why we are here, inhabiting Earth.

It appears that the ideas, hypotheses, and theories put forward by philosophers, scientists and theologians were almost all the products of vivid human imagination. Let us look at what these ideas are.

Aristotle's ideas (384–322 B.C.E.) dominated the philosophic point of view up until the end of the Middle-Ages (or Medieval times) of European history. Aristotle's *Physics*, comprising eight books[1], served as the basis of natural philosophy throughout the Middle-Ages and up until the early modern period. In Book VIII, Aristotle covered the theory of nature and the origins of the universe, with metaphysical foundations of cosmological and physical sciences. Although this book was a significant advancement since man first discovered how to make fire to keep warm, domesticate livestock, and cultivate crops, the progress made in understanding the meaning of our existence has still been insignificant and filled with superstition and dogma.

In those early days, life was all about daily survival. To survive, men figured out they must group together, build social hierarchies and defend themselves against forces both visible and invisible. So, they picked the strongest people as their kings and queens, and formed armies to fight off visible threats. But, invisible threats like lightning, thunder, erupting volcanoes, shaking and roaring ground were more powerful than their kings and queens, and it is this helplessness that made them form deities, organise rituals and chants.

They bowed and worshipped these natural phenomena and made sacrifices for redemption. As always, there were some *clever* people (with vivid imagination) who told them what to do. These were people with status so that they could dominate over other people's lives and wealth. They said "go and build temples". They built those temples, gathered together under the clever guy's leadership and carried out weird and cruel practices and ceremonies to subside the perceived anger of natural elements.

Aztec priests used razor-sharp obsidian blades to slice open the chests of sacrificial victims and offered their still-beating hearts to the sun god Huitzilopochtli[2]. They were scared that if the Sun did not rise in the morning, the darkness would win and the world would end. To keep the sun moving across the sky and preserve their lives, the Aztecs had to feed Huitzilopochtli with human hearts and blood.

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[1] https://en.wikipedia.org/wiki/Physics_(Aristotle)

[2] Human Sacrifice: Why the Aztecs Practiced This Gory Ritual ; https://www.history.com/aztec-human-sacrifice-religion

The practices of the Mayans were equally as cruel. They offered blood, tongues and ears of slaves and prisoners. They made these offerings routinely to please their gods and ensure favour of the gods. Sacrificing your own child by throwing him alive into a water-filled grave was a Maya ritual to please the rain-god Chaak[3]. These beliefs continued as they became entrenched into the human psyche.

Men fear many things. Mysterious things make them afraid, especially if they are a threat to their existence. Fear of drought, fear of losing a beloved one, losing the land you own, losing the country you live in, and fear of death. The wish to feel that you have a kind of protector who will stand by you in all your troubles and quarrels, gave rise to the throning of kings and queens who were in some cultures seen as gods and goddesses.

Ancient Greeks assumed that there were many immortal gods and goddesses, so it was a polytheistic society. In their view there was a hierarchy of deities, with Zeus, the king of the gods, having a level of control over all the other deities. Zeus was the sky-god, sending thunder and lightning; Poseidon ruled over the sea and earthquakes; Hades projected his remarkable power throughout the realms of death and the underworld; and Helios controlled the rise of the Sun.

All significant deities in ancient Greece were visualised as living gods in human form, although often able to transform themselves into animals or natural phenomena.[4] All of these gods and goddesses were the result of stunning human imagination, which eventually extended to the rise of one-god religions.

Aristotle's teachings were gradually discarded with the development of the scientific method and starting from the time of Galileo in the 16th century[5] advanced technological tools such as the telescope and microscope became available. Aristotle's teaching that all heavenly bodies move in only circular orbits around Earth was abandoned when Kepler proved that planets move in equally 'perfect' ellipses around the Sun.

Aristotle's idea that the Earth was made of only four elements, namely earth, air, fire, and water, was shelved when mankind discovered atoms, subatomic particles and the forces holding them together.

Nevertheless, deities survived but the number of gods was eventually reduced to one in the Middle East. The monotheistic religions told us that there is only one God and that He is the creator and the

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[3] Reuters Staff, Jan 23 2008, 6:34 pm. Ancient Maya sacrificed boys not virgin girls: study. https://www.reuters.com/article

[4] https://en.wikipedia.org/wiki/Ancient_Greek_religion

[5] Let us note that Aristarchus of Samos (310-230 BCE) predicted correctly that the earth and other planets revolved around the sun and that one rotation of the earth is one day.

protector of mankind, so we should worship and admire Him. According to them this is "the purpose of our existence." Humans quickly realised that even their one-god religions could not stop the natural calamities - the hurricanes, earthquakes, floods, pandemics and plagues.

Apparently, a religious person could not ask critical questions about scripts of the Bible, as such questions will make him question his faith and the very existence of God. As a result, the idea of the existence of a supernatural power became indisputable and unquestionable, so that it was deeply entrenched in our lives starting from childhood.

It was only when human society evolved and the printing press started spreading knowledge and people became educated, that we started to learn that the apparent supernatural power was all nature's own doing and such calamities could be explained.

Archaeologists found ancient figurines carved out of wood, clay or bronze, with god and goddess names. They still put figurines (for example the Virgin Mary, baby Christ, Hindu god statues and Buddha) at prominent places in their dwellings or village squares to affirm their worship. This is really how the concept of deities began and evolved over time.

Even today in the 21st century, billions of people still believe in the existence of one or another form of supernatural being and do things to please their gods, like building temples, making sacrifices, organising rituals and Sunday prayers. According to the Bible (Genesis 22:1-18), God commanded Abraham to offer his son Isaac as a sacrifice. As Abraham was about to carry out God's command, a messenger (an angel) came on behalf of God and stopped him and said "*now I know you fear God*". Abraham then slaughtered a ram instead of his son Isaac. To this day, slaughtering of sheep, cows and camels is still practiced throughout the Middle East. Ironically, Hinduism considers the cow to be a most revered animal because cows represent Mother Earth, as their milk nourishes babies.

Scientists built ever powerful telescopes to gaze deep into the sky, and powerful microscopes to show us that living beings are made of living cells and that these cells were made of atoms and molecules. It is the work of scientists that provides trustworthy explanations about why the Sun rises every morning and sets every evening, about what the twinkling things in the night sky are, and about how our brains and bodies work like an amazingly coordinated factory. The explanations of scientists are based on observation, logic, reproducible experiments, and tangible evidence, instead of spirituality and superstition[6]. Scientists show us that perhaps our existence is not

[6]https://www.huffpost.com/entry/the-meaning-of-human-exis_b_9302398?guccounter=1&guce_referrer=aHR0cHM6Ly9kdWNrZHVja2dvLmNvbS8&guce_referrer_sig=AQAAANPzzMvieciAp5RLiqqWikDgLEUw6NDrPZpG3Bt-iKwX1R0fg3G32kQwPleMgRYTmdIb6NNH-

bestowed upon us by a divine all-powerful creator; but rather via biological evolution over millions of years, from one common ancestor for all living things.

This book tries to find out if the universe randomly and aimlessly evolved from a cluster of atoms (singularity) like a purposeless lottery; or if it was pre-planned and executed by a divine entity, an intelligent designer.

If there is a creator, could this creator be a supernatural entity, a God? Or, has the universe (Nature) created itself? Together, we will try to figure out if god (or gods) created humans, or if it was human imagination which created the gods.

To get to the bottom of things, we have to start discussing how we have evolved from a universe which seems to be made out of *nothing*, and then we will explain that *nothing* is actually *something*, that we call Substrate.

We also tackled questions like: why does every living being once it has come into existence try to survive and continue to exist? What is the source of this motivation, where does this desire to remain existing come from? We have presented some interesting answers.

Finally, the other aim of this book is to provide some guidance to younger generations, mainly to university students, ones willing to investigate things further rather than accepting blindly what someone else tells them. We have highlighted that ideas, opinions, and hypotheses evolve over time in the hands of inquisitive minds.

This book is organised into 14 Chapters, including the Introduction, Summary and Conclusions as follows:

Following an introductory Chapter I, in Chapter II we examine who we are. Do we play any role in the existence of the things around us? Is what we see around us all a mirage, an artefact created by our minds? Will the universe vanish in a puff of smoke if the conscious minds of humans do not exist? Is there any substance in such a human-centric point of view? Is our existence really so important for the universe? We answer all these questions by saying that everything around us is nothing but a bunch of vibrating clusters of atoms, and we happen to have receptors to sense these vibrations and convert them into names, shapes, and dimensions - something like a radio, a mobile phone or a TV set.

cbFKZGqmqQ9HmYSWHsA5cCTAOkoKbEqcXMiV7oVE6KLBTZDxlt-AEkmYdcVbgenPhG8uS44jI1gjlmBR8Uk37Rw8fbPW3C-t6Im

Chapter III discusses how the world around us is impressively detailed, functional, and mesmerizingly beautiful. This prompts us to wonder who the designer and builder of all these mind-boggling creations might be, if there is one.

In Chapter IV we examine the concept of whether a divine entity or entities - some gods and goddesses - could be the creator of everything. We discuss religious views and the views of the creationists, the believers of intelligent design and ask how and why billions of humans can believe in a supernatural power. We quote sections from the Bible to support creationist point of views.

Chapter V talks about biological (natural) evolution, an alternative to the supernatural, and presents supporting evidence for the evolution theory from palaeontology – fossil records, comparative anatomy, biogeography, embryology, and molecular biology. We also discuss other forces that drive biological evolution such as gene shuffling, mutation, inbreeding and environmental factors like exposure to radiation and natural and man-made chemicals.

Chapter VI discusses the current scientific views about the formation of the universe and the eventual formation of the Earth. Such a discussion is needed because biological evolution is a younger subset in the history of the evolution of the universe. There would be no amino acids, no organic molecules, and no life if there was no universe, no Sun and no Earth. We list what prerequisites must be met to start biological evolution on Earth and establish that biological evolution needs land, water, and breathable air to evolve into the presently living organisms. It is the universe that supplies the ingredients of biological substances: the atoms of carbon, hydrogen, oxygen, nitrogen, and others, to make the molecules, tissues, organs, and living beings.

In Chapter VII we discuss some remarkable aspects of life on Earth. We see that life has its own prominent characteristics and generalities that are mostly agreeable with the laws of chemistry, physics, and biology.

In Chapter VIII, we discuss where and how life emerged from lifeless organic molecules and turned first into a single-cell and then into increasingly more complex multi-celled organisms, plants, and animals. We explore several possible starting locations for the origin of life, including tidal pools, hot springs on land and under deep oceans, and even extra-terrestrial sources. These were the places where there was water, chemicals, and energy sources to initiate life. We devote a section in this chapter to discuss experiments which have been carried out to prove if life can be created in a laboratory out of inorganic matter.

In Chapter IX we discuss how life emerged and talk about a diagram, called a phylogenetic tree (also referred to as “the Tree of Life”) that shows the genealogical affinities of the same class of living

beings. This diagram illustrates that all life currently existing on Earth evolved from a last universal common ancestor (LUCA). We discussed how human beings relate to monkeys through a common ancestor, and then talked about when, where and how our species originated, namely the rise of us - the Homo sapiens.

In Chapter X we ponder what machinery makes humans tick, and talk about the workings of our vital organs like our heart, lungs, and brain. This chapter was to highlight how impressive their design, building and operations are. We also discussed what reality is and reviewed how consciousness arose, and how memories and decisions are made in the brain. We surprised ourselves when we realised that all this can be explained by science, with facts and figures. We deeply admired scientific explanations that told us what makes the heart tick and how a tiny cell works like a huge factory that can even dispose of the waste it generates.

The purpose of Chapter XI is to encourage us to think differently, unconventionally, and to introduce a new perspective on our understanding of the origin of the universe and meaning of our existence. There we present a number of new ideas, some of which may be perceived as outrageous - what I call thought-provoking or even revolutionary. They are merely intended to provoke intelligent minds to think differently and consider that there could be other ways to explain the origin of the universe rather than saying it was created out of nothing.

In this chapter, we put forward our own idea that "nothing" is another realm, which we refer to as the Substrate. We explained the Substrate is a three-dimensional, infinitely large space that existed before the creation of our universe. In this chapter, we also claim our universe is going through a runaway kinetic energy stage generated by the Big Bang and conclude that the universe would have ended as soon as it started if the energy release from the Big Bang was not utilised. The decay of the universe to its absolute ground state - its imminent death – partially curbed when some of the runaway kinetic energy was converted to potential energy and stored in silos like galaxies, stars, planets, on Earth, and in living beings. In this chapter we say that living beings are the most effective energy storage silos as they can reproduce and theoretically continue to exist forever.

In Chapter XII we tackle big questions like why every living being wants to continue to exist. What is the motivation behind the survival instincts of living beings? And then we talked about Richard Dawkins' *Selfish or Immortal Gene* theory. We say that not only selfish genes but the entire universe wants to *survive and continue to exist*. We hypothesize that all living and non-living beings, the potential energy silos, are here to delay the universe reaching the absolute true vacuum (or ground) state - the motionless, vibrationless, dark and freezing cold, the *death* state - integrating back to the Substrate, the space from which it originated.

Chapter XIII talks about how things around us, including us, originated. Was it all accidental? Does nature know what it is doing? We have selected three answers to these questions from published literature: Firstly, that it is all accidental and out of chaos; secondly, that every quanta and every atom and elementary particle stores bits of information from their interactions with other atoms and particles by flipping the bits into a new arrangement; and thirdly, the autodidactic origin idea which goes a step further and suggests that the universe itself may be a type of intelligent and self-improving machine, capable of exploring and discovering new knowledge about the world. We left it to you to choose the right answer, but we chose the idea of all accidental and formed out of chaos.

Chapter XIV – the final chapter provides an extended summary and draws conclusions about the meaning of our existence and why we and everything else exist.

When you read this book, you will realise that scientific explanations of the existence of the universe and its creations are not complete. There are still many gaps to be filled. We admit that only in the last 300 or 400 years have we seriously attempted to understand what Nature has created over the past 13.8 billion years. Even so, of the last 400 years, many of these were wasted to get rid of nonsense, myths, superstitions and traditional beliefs. Yet, in the 21st century, 85% of humanity still believes in one form or another of religion. We wondered how this could be and found that religious beliefs defending supernatural powers as the creator have been entrenched in human society for thousands of years through rituals, bells, and whistles since childhood. In contrast, science, which defends Nature as the creator of everything including us - based on facts, figures, and proven evidence - has been left to scientists whose language is often so convoluted and confusing that even the average university graduate finds it hard to understand. Besides, they often kept themselves busy criticizing each other's ideas instead of collaborating to integrate their concepts into one final, credible theory that is understandable to ordinary people on the street. The commercialisation of scientific information, copyrights, and patents are other impediments to the wider delivery of scientific knowledge.

You don't have to be a physicist or biologist or an astronomer to read this book. It is written for the level of a university student or a high school graduate. In this book, it was inevitable and necessary to use scientific, biological, and medical terms; however, we tried to explain them in the manuscript and in the footnotes as much as possible. For more in-depth understanding of such concepts and the definition of terminologies, please refer to proper textbooks, dictionaries, and internet links like: https://www.ncbi.nlm.nih.gov/books/NBK21052/.

In this book, the author often refers to himself as "we" instead of "I". In this case, "we" means the author and his subconscious, not Austin Powers' "Mini Me" or any other person.

CHAPTER II: OUR PLACE IN THE UNIVERSE

In this chapter we will discuss who we are and try to answer questions like: What role does our existence play in the big wide universe? How important is our species for the universe? What makes us sit on top of the food chain (or pecking order) on our planet? Some people say that everything is a mirage, an artefact created by the human mind - is this true? Would the universe vanish in a puff of smoke if we humans did not exist?

Who Are We?

We are the children, part and parcel of this universe like every other living and nonliving thing. We, and everything else in this universe, are made up of atoms that were formed starting from the creation of the universe 13.8 billion years ago. The atoms that make living cells, our hearts and our brains are as old as the stars in the Milky Way: the galaxy which hosts our solar system and the Earth.

The elements that make the human body in percent mass are: Oxygen, 65.0%; Carbon, 18.5%; Hydrogen, 10%; Nitrogen, 3.2%; Calcium, 1.5%; Phosphorus, 1.0%; Potassium, 0.4%; Sulphur, 0.3%; Sodium, 0.2%; Chlorine, 0.2%; Magnesium, 0.1 %, and all other trace elements including iron, <0.1%. Among them hydrogen was created during the Big Bang and the others are later from the ashes of dying stars.

Four elements (oxygen, carbon, hydrogen and nitrogen) are the main constituents of organic molecules such as fats (lipids) and proteins. In mass percentages, a body is made up of 65% water, 30% proteins, 12% lipids, 1.5% other inorganics, 1% RNA, 0.1% DNA and 0.4% other organics[7].

We humans are biological machines. The human machine works by inhaling oxygen from air and exhaling carbon dioxide. Oxygen is distributed to every organ in our bodies via a pumping system which works 24/7 for our lives. The pump (our heart), performs much better than the engine of the best car on the market for at least the first 50 years of life, and if you do not misuse (or abuse) it, then it can last up to 100 years or even longer. We eat food to run this engine.

Isn't it amazing that when you breathe in, air enters your lungs, and oxygen from that air moves to your blood? At the same time, carbon dioxide, a waste gas, moves from your blood to your lungs so you can breathe it out. This amazing process is one of the essentials of life. Besides delivering oxygen to the cells in your body and removing waste gases, lungs warm the air to match your body temperature, as well as moisturise it to the humidity level that your body needs.

[7] https://en.wikipedia.org/wiki/Composition_of_the_human_body

When you look at the machinery of the human body and understand how the heart, lungs, brain, kidneys, liver, and everything else works, you inevitably start wondering who designed, assembled and made these walking, talking, thinking intricate human beings.

Who designed and made the slithering snake, the show-off peacock, the acrobat dolphin , the grass, magnolias, little ants, flying birds, buzzing bees and milk giving cows as well as us?

What about non-living things like rocks, mountains, sand, oceans, forests on Earth, and the stars, comets and galaxies?

How did it all come into existence?

Most of us think we are important (at least the Bible says so), but are we really? We could be important but certainly insignificant in the space we occupy and time that we exist in.

It is highly likely that we might be one of the few living beings in our galaxy who can comprehend the marvels of what this universe has created, thanks to our minds which give us consciousness, self-awareness, forethought, reasoning, imagination and comprehension, besides many other qualities.

Wikipedia[8] defines consciousness as a sentience, the ability to experience sensation, wakefulness or awareness of internal and external existence. It is also synonymous with the mind or an aspect of the mind or introspection, private thought, volition, imagination, feelings, perception, cognition, and self-awareness, or all the mental processes of the brain.

Humans have a far more advanced brain than the brain of any other animal. Our brains have a much higher capacity to receive, synthesise, draw conclusions, and decide which actions to take. We can reason, talk with each other and remember our conversations. We can imagine things and we can then build the things we imagine.

Not only do we have advanced brains, but we also have the faculties of our arms, legs and fingers to design and build things. We can store and pass on knowledge fast and worldwide. These and many other qualities put us up on top of the food chain and make us the most advanced living being on Earth, our home planet.

A Frisbee for a dog is something to catch in the air, but the dog has no idea the thing it catches is made from plastic, a waste material of a petroleum refinery. A child also will not know what a Frisbee is until his sister or parents tell him those names and explain how they were made. Once told, the child will remember them all. A dog will remember the Frisbee the next day and would

[8] https://en.wikipedia.org/wiki/Consciousness

want you to throw it again, but it will not know that its shape makes it fly even if you told him. Dogs do not have the mental capacity and faculties to throw a Frisbee back to you, but they still associate the Frisbee as something fun to play with. This does not mean that all dogs are dim. The livestock mustering Australian kelpies are very clever. How about the Brazilian collie playing footvolley on the beach with humans?[9]. A dog passes the ball with precision to a man in a footvolley game on a Brazilian beach. They are not all dim at all.

In comparison to other animals, human beings give names to objects and teach these names and every relevant aspect of those objects to their siblings and students. This passing of knowledge to others and disseminating it to a wider audience is a very human thing.

Mothers are mothers whether they are human, bear, dolphin, whale, or chimpanzee. Animal mothers also teach skills to their youngsters,[10] but the skills they teach them are limited to a few things like hunting, swimming, and flying – namely, survival skills. Here are some examples:

●A baby seal learns how to swim by riding on his mothers' back.

●Lion cubs learn to hunt from their mother.

●Baby bears learn what to eat and what not to eat in the wilderness from their parents.

●Polar bears teach baby polar bears how to snatch salmon out of a stream.

●Whales teach their calves where to find the best food in the vast ocean.

Animals, like humans, learn by watching, observing and mimicking their parents and other animals. But only humans, once they learn something, have the mental capacity to improve it and employ this knowledge laterally and use it in many other ways.

A mother deer teaches her fawn to keep away from man by showing exaggerated fear at the sight or scent of man. When a mother wolf comes near a man-set-trap with her cubs for the first time, she shows overstated fear. Her young ones see her reaction and learn that traps are to be avoided.

Baby elephants would not know what to do with their trunks without being shown by their parents. They learn to use their trunk to eat and drink by watching their mother and other elephants when they reach the age of around 6 to 8 months. The mother elephant also teaches them to cover themselves with mud to ward off sunburn.

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[9] Brazilian dog, a 3-year old border collie named Floki, plays footvolley, a combination of soccer and beach volleyball with three humans in Rio de Janeiro. Source: AP video shot by: Mario Lobada, Sep. 20, 2024. https://apnews.com/video/rio-de-janeiro-brasilia-soccer-brazil-587ad5fc06194c8994df41808a53e415

[10] http://www.bihartimes.in/maneka/animalmoms.html

In the animal kingdom, chimpanzees are the cousins of human beings. Chimpanzees are a bit more advanced in their skills and passing of knowledge to their babies than other animals. Chimpanzees teach their infants how to crack and open hard nuts on stones using a rock. Mothers show the young ones how to use twigs as tools to poke into termite mounts and eat them.

A long-tailed female macaque (a type of monkey) shows her young how to floss her teeth using hair, in the same way that humans use dental floss. They teach this by doing it deliberately very slowly so that the infant learns the process.

Cockatoos use multiple tools to recover cashew nuts placed behind Gladwrap (Mylar or polyester) film in a box first by puncturing the film with a pointy pencil and then putting a longer straw through the hole in order to drop the nut down so they can eat it[11].

Leumer et al. (2024)[12] report in an article in a peer-reviewed scientific journal that some animals know how to use nursing to heal wounds inflicted during rivalry fights. They describe in detail how a male Sumatran orangutan (*Pongo abelii*) utilizes a plant called liana, which is known to contain biologically active chemical compounds like *furano diterpenoids* and protoberberine alkaloids. These compounds are recognized for their antibacterial, anti-inflammatory, antifungal, and antioxidant properties, which help the orangutan nurse his wound.

Animals, like humans, have in-built instincts or innate behaviour. Innate behaviours are controlled by genes, so they do not have to be learned or taught by a parent or a friend. Innate behaviours generally involve basic life functions. All animals including humans have survival, sexual, and social instincts. A caterpillar builds cocoons; salmon swim thousands of miles to where they were born because of their innate instincts. A sea turtle runs to the ocean after hatching, and birds migrate before the winter comes. Spiders make webs, birds build nests, and fish swim instinctively. Baby giraffes know how to walk shortly after they are born. Turtles return to the same beaches they were born 15 years later, to lay their own eggs. Migrant birds fly the same route year after year. A cherry tree knows when to bloom flowers and when to make cherries. There is this strong urge in every living being to propagate and multiply. Aren't these all so impressive?

Although we may be more advanced in cognitive functions than most animals, we are not the best, nor the most perfect living beings to say we are "*the centre of the universe*." We may not have an

[11] https://phys.org/news/2023-02-cockatoos-multiple-tools-fish-cashews.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

[12] Laumer, I.B., Rahman, A., Rahmaeti, T. *et al.* Active self-treatment of a facial wound with a biologically active plant by a male Sumatran orangutan. *Sci Rep* 14, 8932 (2024). https://doi.org/10.1038/s41598-024-58988-7

animal predator on Earth but still a deadly virus like SARS-COVID-2 can wreak havoc and infect over half a billion people worldwide and kill 6.44 million people[13]. We are highly defenceless when Nature hits us with earthquakes, hurricanes, tsunamis, droughts, floods, and bushfires. These natural disasters can devastate whole countries, leaving scores of people dead or destitute.

Humans are advanced creatures but there are some animals in their own right which have their superiorities over humans. A dog has a better sense of smell, an owl or an eagle has better eyesight and a bat or even a fragile moth has better hearing than us.

Which athlete can run as fast as a cheetah or jump as far as a puma? There are animals that can do things that we cannot.[14] There are animals that can run on water, defy gravity, be immortal[15], shape-shift, colour change, do not get poisoned from eating rotten food, regenerate their body parts and even have 360-degree vision. We don't know why evolution did not give us some or all these traits.

Humans have countless in-built character qualities of excellence and flaws. Among us there are those known as nice, polite, respectful, shy, brave, calm, loving, caring, charming, cheerful, creative, curious, dull, clumsy, honest, friendly, funny, gentle, timid, tolerant, generous, happy, helpful, humble, humorous, intelligent, mischievous, joyful, playful, mysterious, peaceful, smart, and wise.

We can cry, read, write, speak, laugh, and fall in love, as we tend to do. We can sit down and discuss abstract things with each other. We are more intelligent than most animals, although there are many less intelligent people among us too. And yet, while we have some excellent characteristics to make us good human beings, some of us can be mean, obnoxious, arrogant, belligerent, bitter, dishonest, bossy, greedy, inconsiderate, judgmental, possessive, spiteful, vengeful, abusive, fanatical, intolerant, manipulative, cruel, wicked, murderous, obsessive, oppressive, paranoid, remorseless, boasting, rude, selfish, lustful, sadistic, masochistic and violent.

These (and many other) characteristics are traits that can define the personality of everyone. It is these characteristics which make us different from each other. We all have these traits but at different degrees of intensity, some are enhanced or suppressed. Some of us can be less

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[13] These are official figures as of 14.8.2022 and these numbers could be higher by the time you read this book.

[14] https://listverse.com/2016/06/21/10-incredible-things-animals-can-do-that-we-cant/ and https://www.quora.com/What-can-animals-do-that-humans-can-t

[15] One example for immortality is the jellyfish, *Turritopsis dohrnii*. It seems jellyfish have figured out how to cheat the born to die cycle. Jellyfish are the one of the few animals that can cheat death by reverting from adulthood back to its polyp stage when threatened with danger or starvation. https://www.webmd.com/healthy-ageing/story/is-there-a-cure-for-ageing?ecd=wnl_spr_021121&ctr=wnl-spr-021121&mb=z%2feWmExLSP91w5XzmeGssKDFD0NIgtkqUeb8XMPKI4k%3d_leadtitlelink More examples: http://www.bbc.com/earth/story/20150622-can-anything-live-forever It also seems tinkering with stem cells and genes will allow humans live longer and even be immortal in not-too-distant future.

temperamental, less devious, and more caring than the others. Although twins may look alike, they still have their own personalities. Nobody is the same as another person. Some differences in twins are due to the divergence in their biological make-up, and some are the effect of their surroundings such as the teachings of their parents, teachers and who their friends are.

It is not only us; most animals also diverge in their personalities, and we see this from their behaviour. Pet owners know this well. My late mother-in-law used to have 5 dogs, Heidi, Sally, Suzy, Tiny and Trixie, all female, and all with different personalities. Tiny, the smallest of all the dogs, was the boss and protective of all the others. Heidi the introvert, a timid character, used to fear lightning and hide under the bed during storms. Sally used to eat quickly like a vacuum cleaner so that she could steal food from others. Suzy was the most happy and cheerful one, whereas Trixie was just the opposite, unfriendly, and snarly.

Our achievements are largely the result of thousands of years of knowledge accumulation. The progress humans made did not happen overnight, but step by step through the discovery of fire, the wheel, the telescope, the microscope, the steam engine, and then the atom, molecules and so on. But most importantly, humans made progress by passing all of this knowledge on to others.

In the early days of our species, the passing of knowledge was done by storytelling. Later, it was done by writing on clay, vellum - a parchment made from calfskin, and papyrus, and then on paper and magnetic tapes and computers. Then, there was disseminating what we knew to multitudes of others through radios, TVs, scientific journals, mobile phones, and eventually the internet.

Human intelligence does not have any boundaries. The knowledge created by intelligent minds is used not only for constructive purposes, but also for destructive purposes. We burn coal, gas and oil in such huge quantities and pollute the environment we live in and the air we breathe. We discovered gunpowder but we turned it into bombs. We extracted uranium from underground to generate electricity that lit our homes and streets at night, but also used it to make weapons of mass destruction.

If human ingenuity did not kick in, we would have been extinct many moons ago. We chopped down forests to make furniture, but we also planted entirely new forests. When we made a mess of the air, we quickly started switching to solar and wind power. We synthesised medicines to fight killer bacteria and viruses. We developed technologies that made us able to send men to walk on the moon and built rockets to land on Mars. We sent satellites to explore beyond the Solar System, but some of the satellites were to spy on others and used for military purposes. Mapping the human genome is one of the greatest achievements of mankind, but there is a lingering danger that one day

this may be weaponized to wipe out an entire enemy race. These are some of the legacies that mankind will leave behind.

A desire to leave a legacy is one of the typical human characteristics. It is this desire that makes some excel in science, others in painting or in singing, dancing, poetry, swimming and in numerous sports. Every scientist hopes to be as well-known as Albert Einstein or Stephen Hawking or Charles Darwin.

The achievements of humans have increased asymptotically since we discovered how to make fire to keep warm and how to use the wheel to run horse carts. We have domesticated livestock and cultivated crops, and built amazing monuments all around the world. No other animal species has managed to make metals from minerals. These are the things that make humans superior over other animals, so that we have earned our place to sit on top of the food chain.

We won our exclusive position among the animal kingdom by gradually clawing and intellectualising our way over the course of the last thousands of years. We are a self-learning system. Our knowledge increases continuously.

Human achievements over time are impressive considering that we are physically one of the weakest and most pathetic creatures on the planet. Evolution puts humans on top of the food chain, not because we have powerful claws or can run faster than a cheetah, or because we have the vision of an eagle or an owl, or the nose of a dog, or 10-stomachs-32-brains-and-18-testicles of a leech[16], but because we are equipped with the best tool of all - our brains.

Our brains have created theories on evolution, relativity and quantum mechanics, and composed symphonies. Our brains have designed the International Space Station to watch stars and galaxies, and to find out if any other living beings are out there. We sent a dog named Laika into space as early as 1957 in orbit around the Earth and later landed men on the moon, put a rover on Mars and brought black dust samples back to Earth from an asteroid known as Ryugu.

It is our brains that make us special. Such a sophisticated organ, our brains are the command centre of our bodies. They give us amazing and unique abilities. Our cognitive skills allow us to adapt to our surroundings and circumstances. We can remember the past and we can imagine the unknown, the future and abstract things, all thanks to our brains.

A brain receives information (a form of energy) that is collected from our five sensory organs, the eyes, ears, skin, tongue, and nose. This collected information arrives to the sensory organs in the

[16]https://www.theguardian.com/lifeandstyle/2018/oct/14/10-stomachs-32-brains-and-18-testicles-a-day-inside-the-uks-only-leech-farm

form of light, sound, pressure, or chemicals with distinct smells like the perfume your partner wears, or the burning taste in your mouth when you eat a hot chilli sopping chicken-laksa in a Malaysian restaurant.

Touch detects changes of temperature and pressure. Light travels as electromagnetic waves and when it reaches our eyes, it is converted into photons - the tiniest particles. When photons of light reach the eye, nerves are stimulated, and visual information is sent to the brain via the optic nerve. Sound is a pressure wave and ears detect pressure changes, in the form of compression and rarefaction, in the air. These five senses are all detected and processed in different parts of the brain, either individually or together if they are complementing each other.

Although we usually refer to our five senses, there are actually other senses embedded in the body that also send signals to the brain. For example, it is our sense of balance that allows us to walk upright without falling over; sensing how hot or cold a room is, sensing the passage of time, the ability to feel the pain of toothache, and knowing your heart is beating faster or sweating when you run to catch a bus. Humans are able to explain in scientific terms the biology, chemistry and physics of every bodily function.

There are some senses that we do not have, but which are found only in some other animals. For instance, we cannot feel electric and magnetic fields around us. Our senses are restricted to receive only a narrow spectrum of electromagnetic radiation, but sharks can detect electric fields and bats can sense the Earth's magnetic field and use it to navigate. Many animals, including insects and birds, use polarised light to decide which direction to go in. Bats use echolocation to hunt and navigate in the dark. They use relatively high, mostly ultrasonic wavelengths, and some can create echolocating sounds up to 140 decibels[17]. Snakes use their tongues to see and smell.

Everything in the universe, whether living or nonliving, is made up of small vibrating atoms. We call this "electromagnetic radiation energy", which comes from the vibration of atoms and molecules of objects. They are all resonating waveforms and pulsating particles at some specific frequencies held together by strong and weak electromagnetic, and gravitational forces. The universe makes them, but the universe does not seem to have a conscious mind or a keyboard to give these vibrating energies a name, and describe their shape. But, we humans have a conscious mind and that is what makes us special in this universe. We are special because we have receptors to sense these vibrations and convert them into names, shapes, and dimensions - like a radio, a mobile phone or a TV set.

[17] https://carnegiemnh.org/detecting-objects-with-invisible-waves-using-radar-sonar-and-echolocation-to-see/

We human beings are one of the greatest achievements of the universe we live in. But, have we evolved just to witness and admire what the universe has created? Could this be the purpose of our existence?

Indeed, if we did not exist, who would know that the universe has ever existed, at least on planet Earth? If intelligent beings did not exist, who would acknowledge its existence? If we did not exist, the universe would be nothing but a bunch of entangled clumps of atoms, lifelessly vibrating clusters of molecules, stars, galaxies, and planets.

We give shape and the fourth dimension, time, to vibrational energies because they are in our brains and genes, which tell us everything we experience in life – everything we see around us must fit into a shape and size or a timeframe. We have the structural (mental) ability to build our own reality, from the vibrations around us. I say our reality because what we build ourselves as reality is nothing more than just lumps of vibrating atoms that leave impressions in our brains. That is why my reality, the way I perceive an object, might be entirely different from the way you perceive the same vibrations. This is because we all differ to some degree in our genetic or biochemical make-up, and in processing the events happening around us.

Let us be clear that there is no need to exaggerate our importance - we admit that we are just one of those clusters of entangled vibrating atoms of the universe, but we can actually think about the fact that we are made of atoms.

In brief, we are just another animal species but with more sophisticated brains and cognitive skills than any other living being on this planet. However, to put it into perspective - our planet is one of approximately 200 billion planets in our galaxy, the Milky Way. The Milky Way is one of 2 trillion galaxies in the universe. Our own senses may think we are important, but we are significantly insignificant in this universe. We are too insignificant to claim that "if we did not exist there would be no universe" and to think "we are the centre of the universe". If we did not exist, the universe would simply remain home to a bunch of other entangled clumps of atoms, living or lifelessly vibrating clusters of molecules, stars, galaxies, and quintillions[18] of other planets.

[18] quintillion - 1 followed by 18 zeros

CHAPTER III: DO YOU SEE HOW IMPRESSIVE THINGS ARE AROUND US?

Albert Einstein said "*Look deep into nature, and then you will understand everything better*"[19]. He is right. If we have looked at things around us, not just superficially but really deep into them, we would have noticed how intriguingly and purposefully designed they all are and how they function so amazingly.

Examples of things in nature that would impress a seeking eye are endless. This makes you wonder whether there is some intelligence behind all of this. Let us give you some examples and share some fascinating facts about things that are around us.

Soft-bodied octopuses are unique among invertebrates, as they have the largest central nervous systems, the greatest brain-to-body mass ratios, as well as being known for their mysterious abilities like changing colour and regenerating their limbs. Yet the most bizarre of all is the fact that the females kill themselves after laying eggs. Because of this self-inflicted death, they are unlike other big-brained animals in that they live an unusually short life - typically for only a year or so. After mating and hatching their eggs, females begin fasting and undergo rapid physiological decline, featuring repeated self-injury and eventually leading to their death. How and why did they develop such an extremely peculiar life?

The answer to this question came from a scientist, Z. Yan Wang and his co-authors[20]. They tell us that the lifespan and reproduction of the octopus are both controlled by their optic glands, and when the functioning of these glands is disrupted, their lifespan and reproduction goes haywire. Wang and his team explain this bizarre maternal behaviour is due to alterations in cholesterol metabolism that forces the optic gland to secrete some kind of self-destruct hormone. How did such a fascinating suicidal mechanism come about? Who put this mind bogglingly intricate process together with octopuses' life cycle?

Each living cell is a collection of many sophisticated factories of miniature scale. If any of these factories is intruded by unwanted bacteria, the cell has a very clever defence mechanism or *bodyguards* to eliminate the intruder. It puts white blood cells into action to chase the bacteria, catch the intruder and consume it. If you want to see the white cells in action, go to YouTube and

[19] https://www.brainyquote.com/quotes/william_cowper_156812

[20] Z. Yan Wang et al., (2022). Steroid hormones of the octopus self-destruct system, Current Biology. DOI: 10.1016/j.cub.2022.04.043 https://www.cell.com/current-biology/fulltext/S0960-9822(22)00661-3?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0960982222006613%3Fshowall%3Dtrue and https://phys.org/news/2022-05-cholesterol-production-tragic-octopus-death.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

click on the link: https://www.youtube.com/watch?v=AUih856vaQY. It is like a leopard chasing a gazelle but, in this case, the white blood cell does not have a brain or a mother to learn from.

What makes such a thing possible? Here is the scientific answer[21]: White blood cells(lymphocytes) are immune system cells. They are like warriors waiting in your bloodstream to attack any infection by surrounding them. The white cell attacks the invading bacteria, viruses, fungi or parasites using specific antibodies and antitoxins. These cells detect antigens - proteins on the surface of pathogens which are different to the surface markers on the body's own cells. When they identify antigens as foreign to the body, they produce antibodies against them which stick to the antigens and make it easier for the other parts of the immune system to identify, destroy and remove infective agents (op.cit). For example, if the allergen is pollen, they release histamine. This chemical acts on the body's cells causing effects such as coughing, sneezing and a runny nose. This response is designed to expel the allergen from the body.

It appears that pain is more than an alarm bell to warn us against any harm or threats to our body. When something goes wrong in the body, we feel pain in the guts and the stomach. This warning system has been long recognized as one of biological evolution's most reliable distress signalling tools. A study on mice[22] indicates that pain is designed not only as a signal that alerts us to something being wrong, but it is also a form of protection. According to this study, the nervous system sends a cascade of signals to the gut's linings. In this communication, pain neurons engage in direct crosstalk with mucus-containing epithelial cells lining the cells of the intestine and tell them to release more protective mucus to protect the guts from inflammatory conditions such as colitis. Scientists' explanation of this communication and some further details can be found in a CELL article linked in the footnote below[23].

The retina of the eye is arguably the most important part of the eye, and it is an amazing design. The retina has an outer blood-retina barrier which consists of the retinal pigment epithelium, separated by Bruch's membrane from the blood-vessel rich choriocapillaris. Bruch's membrane regulates the exchange of nutrients and waste between the choriocapillaris and the retinal pigment epithelium. Age-related macular degeneration (AMD) starts in the outer blood-retina barrier. In AMD, lipoprotein deposits called drusen form outside Bruch's membrane, impeding its function. Over

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[21] https://www.blood.co.uk/news-and-campaigns/the-donor/latest-stories/functions-of-blood-its-role-in-the-immune-system/

[22] https://www.sciencedaily.com/releases/2022/10/221014135619.htm

[23] Daping Yang, Amanda Jacobson, Kimberly A. Meerschaert, Jay R. Thiagarajah, Samantha J. Riesenfeld, and Isaac M. Chiu (2022). Nociceptor neurons direct goblet cells via a CGRP-RAMP1 axis to drive mucus production and gut barrier protection. DOI:https://doi.org/10.1016/j.cell.2022.09.024; https://www.cell.com/cell/fulltext/S0092-8674(22)01196-5?_return URL=https%3A%2F%2Flinkinghub.elsevier.com%2f Retrieve%2fapi%2FS0092867422011965%3Fshowall%3Dtrue

time, the retinal pigment epithelium breaks down leading to photoreceptor degeneration and vision loss[24].

Further unravelling the mysteries of existence, what drives atoms to be ordered into a grain of salt or into ice crystals? What makes two strands of DNA curl around each other to make a helical shape? Why do quartz crystals have a pointy end? What makes a star-like snowflake crystal[25] to such great perfection?

Is it not amazing to watch atoms weaving and growing into particular crystal shapes in an astoundingly orderly and symmetrical fashion? Each individual atom is located at precise intervals and knows to keep the same orientation compared to the others.

Isn't it amazing to watch every living thing being born small, grow bigger and then die? How impressive is it to watch blossoming cherry flowers turn into bright red cherries, or for a male peacock stretching its wings to show off his colourful feathers to attract a female for the continuum of its species. The female peahens have much duller colours and the reason for that is the need for camouflage so that they can guard the eggs and chicks better.

Dandelions have a unique mechanism of dispersing their seeds long distances by using the wind. They have a seed design that looks like the propeller of a drone, filaments that radiate out from a central stalk, like the spokes on a bicycle wheel and features that seem to assure they disperse far away in their flight[26]. Moreover, to maximise their propagation chances further, each dandelion plant produces approximately 15,000 seeds at a time (op.cit.) to guarantee a maximum number of propagations in a harsh environment. Who could come up with such a clever design?

How did a gumtree, *Eucalyptus*, learn to survive recurring bushfires? How did some species even learn to use the bushfires as a tool for their seeds to sprout? Who thought that charred soil would break their seed dormancy[27]?

Isn't the communication between the egg and the sperm to decide if your child will have your brown eyes or your wife's green eyes so admirable?

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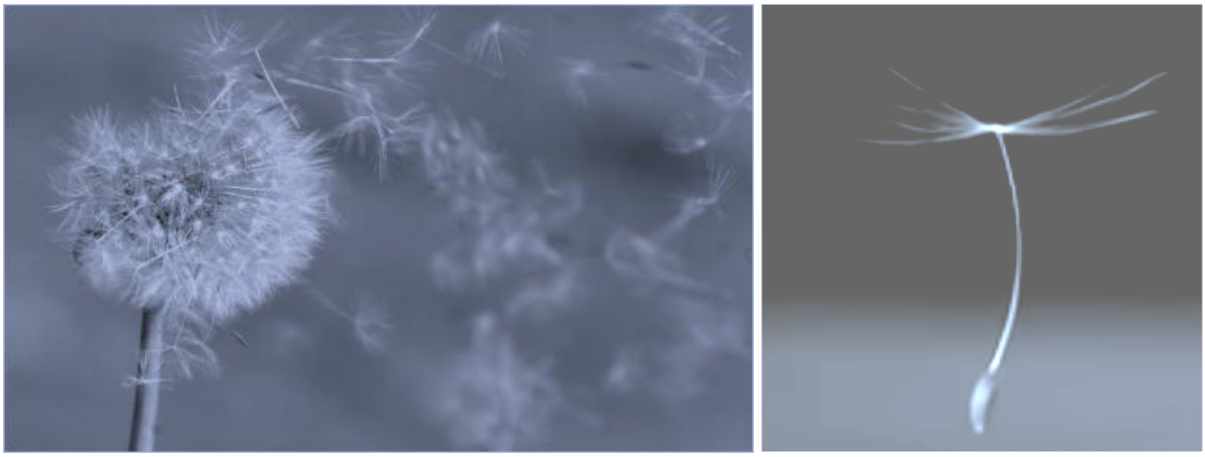
[24] Kapil Bharti, Bioprinted 3D outer Retina barrier uncovers RPE-dependent choroidal phenotype in advanced macular degeneration, Nature Methods (2022). DOI: 10.1038/s41592-022-01701-1. www.nature.com/articles/s41592-022-01701-1

[25] https://www.sciencenewsforstudents.org/article/how-snowflake-made

[26] https://www.nature.com/articles/d41586-018-07084-8 Dandelion seeds fly using 'impossible' method never seen before in nature.

[27] https://www.britannica.com/list/5-amazing-adaptations-of-pyrophytic-plants



Dandelion seeds blown away by wind to ensure they disperse far away.

Every year, salmon travel up to 4,000 kilometres from the Pacific Ocean to the rivers of Asia's Kamchatka Peninsula. They leap over waterfalls and dodge hungry bears, eagles, and seals along the way just so they can lay eggs in the same place that they were born, known as their "*spawning ground*". Salmon can live for up to seven years, so it's quite remarkable that after all that time, they can find the exact place where they were born.

If you are really wondering how they do it, as always there is a scientific explanation[28]. Salmon seem to have magneto-reception, meaning they can detect the magnetic fields of Earth which helps them figure out the right way to go. It's like a GPS built into their brains. Scientists also think salmon have an advanced sense of smell. Researchers believe that salmon can sniff out chemical clues in the water, which can trigger their memory that will lead them to their spawning ground. Isn't it amazing to know how salmon have acquired all these advanced senses?

David Attenborough's[29] *Planet Earth* and Chris Pacham's *Animal Einsteins* documentaries show numerous examples where plants and animals employ mind boggling strategies, deception, and feats of engineering to survive and multiply to remain in existence. For example,[30] wild oats, a type of grass seed, literally walk to find a suitable location to germinate. The seeds of each wild oat have two bristles called awns. Once the seeds fall to the ground, these two awns help them do the walk. When a seed drops to the ground, the awns twist as they dry out during the day and then untwist when they get wet. Tiny hairs grip onto the ground, keeping the seed moving forward until it finds a suitable spot in the ground to germinate. Amazing to watch!

[28] https://www.cbc.ca/kidscbc2/the-feed/for-salmon-laying-eggs-is-a-dangerous-adventure
[29] For example, in BBC's Planet Earth Series: https://www.youtube.com/watch?v=DMP8ctjk6TQ
[30] https://www.youtube.com/watch?v=NlUparIDfzE

Or watch how a sneaky orchid flower tricks a wasp[31] and see how they hoodwink hapless male wasps to get pollinated. Although orchids produce stunning flowers, about 30% of them don't produce nectar, so visiting insects do not pollinate the flowers. This handicap made orchids develop a sophisticated sexual trickery.

Orchids do this trickery by releasing an odour (pheromone[32]) like a female wasp would release when she is ready to mate. Orchids have adopted this strategy to deceive male wasps, known as thynnines, into believing that they've found a female wasp. The female wasps are chubby, flightless creatures that spend much of their adult lives underground, laying eggs on beetle larvae in the soil. When a female thynnine is ready to mate, she crawls out of the ground and releases a pheromone to attract males.

The orchid even figured out to synchronise its pollination time with the brief mating season of the thynnine wasp. The flower of the orchid not only mimics the smell of a female thynnine wasp, but it also has the same shape and colour of the female wasp and even sits at the same height as the wasp does. The duped male wasps even start fighting with each other when other males have picked up the same scent.

Did you know that the cells in our body are also able to fend off germs with "cleaning" products, some antibiotics in the form of a protein that acts like a detergent?[33]. A human apolipoprotein L made throughout much of the body, with detergent-like activity, killing intracellular pathogens. It is this molecule which wipes out invading bacteria, like a detergent attacking an oily stain, by dissolving bacterial membranes. But what or who tells the cleaning product to come to the body's aid? Scientists find that an alarm signal known as interferon gamma, mobilises them. It is this signal telling the protein to crank up its production and fight the pathogens. Isn't the design of such a system impressive?

Plants, fixed in soil, face a constant threat from pathogens in the soil, so they too have developed their own sophisticated defence strategies to fight against them. One of these strategies, found by Yale University, involves an innate plant immune protein known as guanylate-binding protein. It is

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[31] https://www.youtube.com/watch?v=6yLnKfhmUzg

[32] Pheromone is a chemical substance produced and released into the environment by an animal, especially a mammal or an insect, affecting the behaviour or physiology of others of its species. https://www.australiangeographic.com.au/topics/science-environment/2014/09/deceptive-orchids-luring-wasps-for-pollination/

[33] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8422858/ Ryan G. Gaudet, et al., A human apolipoprotein L with detergent-like activity kills intracellular pathogens" Science. 2021 Jul 16; 373(6552): eabf8113. doi: 10.1126/science.abf8113; PMCID: PMC8422858; NIHMSID: NIHMS1736936; PMID: 34437126

this protein which creates liquid-like compartments within the cell nucleus that drives the activity of host defence genes during infection[34].

There are so many bizarre animal and plant behaviours. One wonders how and why they are all possible. Who thought of these insanely fascinating things? Here some more examples:

The sex life of animals is also captivating. Did you know that a female anglerfish mates by fusing her body with many male anglerfish? In this process, their bodies and circulatory systems fuse together so they all become one fish. Could this be their solution for eliminating competition among them?

Marine flatworms have both male and female reproductive organs, which makes their sex life a bit saucier.

The biggest male clownfish morphs into a female and then starts mating with male clownfish.

A little mouse-like marsupial called a male antechinus, has a sex life so intense that in the mating process his fur starts falling out, he bleeds internally, he goes blind, and then dies. What a way to go!

Who says you cannot have a virgin birth? In the absence of males around, female pythons and Komodo dragons can reproduce via a cloning mechanism. They fuse their eggs with other materials in their own bodies to clone their embryos. We know this as a fact because the baby pythons and Komodo dragons have the same DNA as their mothers.

When male and female salamanders mate, they first do a sort of dance ritual and then the male drops a translucent blob that contains his sperm. The female then sits on it to get her eggs fertilised.

Like humans, some animals such as spiders also give gifts like a tasty insect to females but with the sole purpose of enticing them into mating. It is even more interesting that they wrap their gift spinning their own silk in something like the way we wrap up our Christmas gifts in shiny wrapping paper.

Who says animals don't show affection and don't do romance? Male and female bald eagles do mid-air acrobatics, like tumbling and doing cartwheels together, before building a nest. In their new nest, they show their affection to each other by sitting shoulder-to-shoulder, picking each other's fleas, squealing to each other, and finally mating. They remain faithful to each other, staying together and raising their chicks until their death.

[34] https://news.yale.edu/2021/05/26/how-plants-ward-dangerous-world-pathogens . How plants ward off a dangerous world of pathogens, By Bill Hathaway, May 26, 2021

It's a dangerous world out in nature, so animals must evolve good defenses so they don't end up being the dinner of a predator. They had to be creative and had to develop breathtaking methods both to defend themselves and to prey on their victims. For example, assassin bugs (Family *Reduviidae*) carry a ball of dead ants that they killed before, on their backs to deceive spiders, their major predator. The assassin bugs somehow know that these spiders do not like eating ants, because ants bite and use chemical weapons.

The way assassin bugs kill their prey is also interesting. They inject their saliva that turns the contents of the prey's body into liquid. The bug then sucks up the juices through its proboscis, which acts like a straw[35].

The war between native Japanese honeybees and Asian giant hornets is fascinating. If a single hornet gets into a beehive, it can kill multitudes of bees by ripping their heads off. But the bees also have developed a formidable and unique defence against the intruder. Hundreds of the bees gather around the hornet and then vibrate vigorously. All the bees buzzing together generate so much heat, that they cook the hornet to death[36].

There are so many other strange behaviours developed for other reasons. For example, most dog owners would know their dog loves to sniff the rear ends of other dogs and every tree trunk and fire hydrant if there is some pee from another dog. They do this to learn the other dog's identity, or to know if they've met before, or to find out its gender. It seems that dogs have developed sniffing to communicate, since they cannot talk like us and ask each other questions. Scientists tell us that what the dogs are sniffing is certain chemical compounds.

This pee and bottom-sniffing action is just one of many examples of chemical communication in the animal kingdom. It's somewhat akin to communicating through chemicals. It resembles the act of speaking with chemicals. Dog's rear end has a small pouch called anal sac where apocrine and sebaceous glands are found. Scientist discovered that the primary chemical compounds that produce a dog's aroma are trimethylamine and a number of short chain acids[37]. Dogs have a very sensitive snout, a hypersensitive nose called the Jacobson's organ. This organ is designed specifically for chemical communication and has its own set of nerves leading directly into the brain (op.cit).

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35 https://www.seas.harvard.edu/news/2021/08/robot-mimics-powerful-punch-mantis-shrimp

36 https://www.reuters.com/article/us-japan-bees-idUSBRE82S0AZ20120329

37 https://www.britannica.com/video/187069/dogs-each-other Why do dogs sniff each other's butts?

Even more bizarre is the male giraffe. He must taste the female giraffe's urine to find out if she is ready to mate. He somehow knows her urine will taste different when there are certain hormones in it.

Did you know that sea cucumbers breathe through their anus? Orchids do this trickery by releasing an odour (pheromone[38]) like a female wasp would release when she is ready to mate. Orchids have adopted this strategy to deceive male wasps, known as thynnines, into believing that they've found a female wasp. The female wasps are chubby, flightless creatures that spend much of their adult lives underground, laying eggs on beetle larvae in the soil. When a female thynnine is ready to mate, she crawls out of the ground and releases a pheromone to attract males.

The mantis shrimp can break shells of snails or crabs by its powerful hits. This karate punch is so powerful and fast, that for a split second it heats the water around it to almost the temperature of the sun. Interested readers can find more details of how such a small creature without the muscle of Hercules has developed such an intense striking power at the link below[39].

Did you know that dolphins can sleep with one eye open, because one half of their brain remains awake during their sleep? It is even more interesting to know that after about two hours, the alert part of their brain goes to sleep and the other side of their brain wakes up and takes over. It seems that this mechanism has developed because the dolphins know they wouldn't be able to breathe if they are completely asleep.

How did bats evolve with echolocation abilities, like radar devices switching between active transmitters and passive receivers and using ultrasonic wavelength sounds higher than a military jet taking off? In order to avoid such deafening sounds, bats developed a mechanism that controls the muscles in their middle ear to pull apart bones that carry sound waves to the inner ear, leaving no path for the sound waves to damage their cochlea[40]. Bats restore their full hearing a split second later to listen for echoes. With such a skilful design, bats can detect an insect up to 4 to 5 metres away and determine its size, shape, hardness, and direction of travel.

Who says plants don't eat meat? Why and how did the Venus flytrap[41] evolve its ability to obtain meat for sustenance? Isn't it an amazing design that its lobes snap shut only when a fly steps in? It

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[38] Pheromone is a chemical substance produced and released into the environment by an animal, especially a mammal or an insect, affecting the behaviour or physiology of others of its species. https://www.australiangeographic.com.au/topics/science-environment/2014/09/deceptive-orchids-luring-wasps-for-pollination/

[39] https://www.seas.harvard.edu/news/2021/08/robot-mimics-powerful-punch-mantis-shrimp

[40] https://carnegiemnh.org/detecting-objects-with-invisible-waves-using-radar-sonar-and-echolocation-to-see/

[41] Hedrich R, Neher E (March 2018). "Venus Flytrap: How an Excitable, Carnivorous Plant Works." Trends in Plant Science. 23 (3): 220–234. doi:10.1016/j.tplants.2017.12.004. PMID 29336976

seems that this plant has a rudimentary form of memory, in which trigger hairs must be stimulated within 30 seconds in order to result in trap closure (op.cit). This memory isn't encoded in the brain, as plants do not have a brain.

A great example of adaptation to extreme environments is pressure tolerant organisms – piezophiles – living in deep ocean waters. Scientists[42] have found out a chemical called trimethylamine N-oxide (TMAO) in cells of marine organisms, which enables them to survive high pressures of deep oceans like the Mariana Trench of the Pacific, approximately 11 kilometres below the sea surface where the overload pressure increase is 1,100-fold higher compared to the Earth's surface[43]. And yet, life has adapted to survive and thrive in such an extreme environment.

Apparently, the presence of this TMAO molecule strengthens and stabilises the hydrogen bonding and stops the water molecules collapsing. In the absence of TMAO, the hydrogen bonds in the pure water sample would become distorted and less stable and the overall network of water molecules would be compacted. This would lead to the death of the organism. The evidence they present is a measurable increase in the TMAO concentration in muscle tissue of bony ray-finned fish and in cartilage skeletons of jawed fish with increasing depth.

You may know that close to the end of its life cycle, the caterpillar stops eating, hangs itself upside down from a twig or leaf, and spins a silky cocoon known as a chrysalis, around itself. The caterpillar eventually emerges out of the chrysalis as a butterfly or moth. How a caterpillar rearranges itself into a butterfly is most fascinating, because within the cocoon, the caterpillar radically digests itself to become a protein mush. Please click on the Scientific American link[44] if you want to know the details of this process.

If you really want to learn more about the marvels of nature and are wondering if there is an intelligence to design such sophistication, just go and watch David Attenborough's documentaries.

In summary, we have now highlighted how sophisticated, purposefully designed and constructed the things around us are. It is as if there is an intelligent designer and an amazingly talented builder

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[42] Harrison Laurent et. Al., 2022. The ability of trimethylamine N-oxide to resist pressure induced perturbations to water structure, Communications Chemistry volume 5, Article number: 116 (2022). DOI: 10.1038/s42004-022-00726-z , www.nature.com/articles/s42004-022-00726-z.

[43] Although the water is generally known as not compressible (or compactable) at such high pressure seawater is slightly (not negligibly) compressible. This can be seen from the increase in the density of seawater from 1.02813 at sea level to 1.07104 g/cm3 at a depth of 10,000 m. According to Encyclopaedia Britannica: If seawater were incompressible, each cubic centimetre of water in the water column would expand, and density values at all depths would be equal. https://www.britannica.com/science/seawater/Density-of-seawater-and-pressure

[44] [16] Ferris Jabr, 10.8.2012. How Does a Caterpillar Turn into a Butterfly? https://www.scientificamerican.com/article/caterpillar-butterfly-metamorphosis-explainer/

behind all of this. Scientists indeed do great work to find out how it all works, but they fall short in answering the question of *who* designs and constructs them.

Who has the intelligence to know how to put the atoms, electrons, and ions together, and to make all these sophisticated and increasingly more complicated forms of matter, molecules, crystals, rocks, and cells than bacteria, and walking, talking, chirping, flying, and swimming creatures?

Is the designer and builder of all these amazing things a supernatural power with the name God or Allah or Yahweh or one of the Hindu or Buddhist gods[45]? Or is it Nature, a creator, a God-like entity?

If it is Nature, then how does it do it? And why does it do it? Does it have its own mind, its own consciousness? If it is a God, then who is he (or she)? How does he do it? Why does he do it?

We will try to find answers to these questions in the following chapters. Let us first start with the theory that says a supernatural power made everything come into existence.

[45] Buddhists do not believe in any kind of deity or god but have supernatural figures who can help people on the path towards enlightenment. https://education.nationalgeographic.org/resources/buddhism/

CHAPTER IV: THE CONCEPT THAT SAYS GOD IS THE CREATOR OF EVERYTHING

Since the beginning of time, humans have questioned the meaning of their own existence and have proposed many different theories and ideas ranging from the down to earth to the way out. One such theory is the Creation theory[46] of Judaism and Christianity - the creation of life by a supreme being called God.

According to Christianity,[47] God is the creator of the universe, and the Creator is the one and only God and the "maker of heaven and Earth". The Bible (Hebrews 11:3) claims "*by faith we understand that the universe was formed at God's command, so that what is seen was not made out of what was visible*", namely by an invisible creator. "*By the word of the LORD were the heavens made; and all the host of them by the breath of His mouth. . . . For He spoke, and it was done; He commanded, and it stood fast" (Psalm 33:6, 9) and "He commanded, and they were created*" (Psalm 148:5)".

According to the Bible, God has a purpose for everything he creates, including us (Isaiah 45:18). God created us with a "*spiritual need,*" which includes the desire to find meaning in life (Matthew 5:3). He wants us to satisfy that desire (Psalm 145:16). God created us to inhabit the world (Isaiah 45:18). The Bible explains God's purpose for humans in Genesis 1:27, 28: "*Be fruitful and become many, fill the Earth and subdue it*." The Bible states at Ecclesiastes 12:13 "*Have reverence for God, and obey his commands, because this is all that we were created for*."

According to Islam,[48] God (Allāh) is the creator of the universe and all the creatures in it. In Islam, God created everything for a divine purpose; and the universe is governed by fixed laws that ensure the harmonious working of all things. Everything within the universe, including inanimate objects, praises God. In Islam, the creation and ordering of the universe is seen as an act of prime mercy for which all creatures praise God's attributes and bear witness to God's unity, meaning that He is the one and only God; there is no other God.

The Quran is very clear about why God (Allah) created humankind. According to the Quran, Allah created humans only to worship Him (51:56). The more a Muslim worships Allah, the more he or she gets closer to Him and the meaning of existence starts surfacing[49]. It is by reading the Quran that humans can find the answers to the questions of how they came into being and what their purpose on this Earth and in this life is (op.cit.).

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[46] https://www.wisegeek.com/what-is-creation-theory.htm
[47] https://en.wikipedia.org/wiki/God_in_Christianity
[48] https://en.wikipedia.org/wiki/God_in_Islam
[49] http://www.quranreading.com/blog/learn-more-about-your-purpose-of-existence-with-quran-online/

The single God concept is attributed to Abraham, a Jew, in the Christian Bible[50]. After thousands of years of creating new gods to fill all the gaps in our knowledge, one very wise old man named Abraham in the Middle East, while he was sitting near the great trees of Mamre[51] met with three angels where he got the idea of the single God - an all-powerful, all-knowing God who would explain every gap in our knowledge. He became the father of three Abrahamic religions: Judaism, Christianity and Islam.

The modern (Abrahamic) monotheistic religions believe that human beings are made in God's image[52]. In the religious view, human beings are set apart and are assumed to be God's superior beings as we are the only self-conscious creatures in our world. By saying "*God created everything, the heaven, and the Earth*"[53] including humans, the Bible puts humans on top of every other creation and suggests that God gave mankind the responsibility to rule over all other life forms.

According to the Bible, God said "*Let them have dominion over the fish of the sea, the birds of the air, the tame animals, all the wild animals, and all the creatures that crawl on the Earth*." Christianity teaches that God endowed humans with awareness (consciousness), but not animals[54]. God's creations on Earth possessed the capacity for reason, morality, language, personality, purpose, and spirituality. In that sense, humans would stand as God's image, God's representatives, on Earth as we rule over and manage all the rest of His creation[55]. According to Christian creationism, humans are particularly important and in return they were expected to worship God.

According to Christianity, humans (as well as the rest of the natural world, including the universe) were created out of nothing (*creatio ex nihilo*)[56] by one God. In Islam, Muslims name this creator Allah. Christians name Him God, and Jews name Him Yahweh.

Genesis, the first book in the Hebrew Bible and the Christian Old Testament, tells the story of God creating the world and the first humans in six days. The basis for many creationist beliefs is a literal or pseudo-literal interpretation of the Old Testament (op.cit.).

For example, the book of Genesis (Genesis 1:2) describes how God brings the Universe into being[57] in a series of creative acts over six days and places the first man and woman, Adam and Eve, into a

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[50] http://web.mit.edu/jywang/www/cef/Bible/NIV/NIV_Bible/GEN+18.html

[51] the present-day site of the so-called Oak of Mamre, 2 km southwest of Ramat el-Khalil, north of Henron.

[52] https://www.npr.org/templates/story/story.php?storyId=4760816

[53] https://en.wikipedia.org/wiki/God_in_Christianity

[54] There are new scientific studies to show some if not most animals have varying degrees of consciousness.

[55] Although it seems we are not doing a good job.

[56] https://www.britannica.com/topic/creationism Creationism

divine garden known as the Garden of Eden. This story is the basis of creationist cosmology and biology.

The Genesis flood narrative (Genesis 6:9) tells us about how God punished humans who had misbehaved by destroying the world and all life through a great flood, but saving representatives of each form of life with the help of Noah. This story forms one of the bases of creationist beliefs (op.cit.).

Other religions have their own ideas about creationism. Why should the universe be created by the God of people of the Middle East? Why not one of the Hindu gods? Over one billion people worship Hindu gods and goddesses. The holy scripts of the Hindus, known as the Vedas, tell us that Brahma is the creator of the universe[58], Vishnu is the preserver and Shiva is the destroyer of the universe.

The Vedas, the oldest texts of Hinduism, assert that living beings are part of a cycle of creation and destruction that began millions of years ago. Based on this belief, the existence of humans and the rest of the physical world is eternal. Hinduism is the oldest religion based on the complete scriptural tests dating back 3,000 years. Hinduism does not support the concept of biological evolution, as Hindus believe that humans have been unchanged since the beginning of time. Hinduism believes there is another power that is a special word 'OM' and nothing else is greater than the power of this word as it contains the whole universe in it.

Buddhists do not believe in any kind of deity or God. Buddha is considered as an enlightened being but not a god. Buddhists believe that humans can reach Nirvana (the highest enlightenment) by meditation, physical and spiritual labour and good behaviour[59].

In Japan, Shinto is the major religion practised by 3 - 4 million people who believe in the existence of eight million Kami (Gods) - more than the number of its followers.

Besides these major religions, there are also pagans, based on African religions which are a blend of polytheistic traditions and some aspects of Roman Catholicism. The Native Americans and Pacific cultures also each have their own religious traditions and gods.

Human imagination and our fantasies keep creating false gods to fill the gap in their knowledge. Even today among us, there are some people who effectively worship celebrities, football players, pop singers, politicians and any narcissist looking for cheap adoration and idolisation. These are false gods, creations of human imagination and their weaknesses.

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[57] The Bible explains in Psalm 33:6,9: "*By the word of the LORD were the heavens made; and all the host of them by the breath of His mouth. . . . For He spoke, and it was done; He commanded, and it stood fast*" and in Psalm 148:5: *"He commanded, and they were created*".

[58] Brahma: The Hindu God who created the world – Sharp School.

[59] https://education.nationalgeographic.org/resources/buddhism.

The creation of the universe, life, and humankind as described in religious texts is called Creationism[60]. It asserts that a divine creator intentionally designed and created everything, rather than creation occurring through the natural processes of evolution and via scientific explanations.

It is important to understand that Biblical creationism is not the only theory of creation. Like modern scientists, the divine intervention believers are also fragmented in their opinions. This has resulted in the establishment of diverse beliefs and various churches. Such diversification on how life was created is another example of the workings of human imagination with no boundaries. Overall, the diverse versions of creationism are a philosophical and religious belief that is not accepted in the scientific community and is often at odds with scientific understanding and evidence. From the 18th century onward, some creationists accepted geological time harmonised with Genesis through the gap or day-age theory, and supported the progressive form of creationism, yet still rejected the evolution theory.

Some creationists believe that changes in organisms may involve changes within a species (often understood as the "kind" mentioned in Genesis 1:24) or downward changes such as negative mutations, but they do not believe that any of these changes can lead to the evolution of a lower or simpler species into a higher or more complex species. Thus, the theory of biological evolution is disputed by all creationists. Yet, some mainstream Protestants and the Catholic Church reconcile modern science with their faith in Creation and accept evolution. Some groups call their belief "*evolutionary creationism*"[61].

More recently, attempts have been made to separate creationism from the Bible and reformulate it as science referring them as creation science and intelligent design[62].

The Intelligent Design idea was formulated in the 1990s. It is a pseudoscientific form of creationism, and is sometimes referred to as "intelligent design creationism" or "evolutionary creation[63]." Proponents of the intelligent design concept believe that the complexity of life, the mathematical improbability of life occurring spontaneously, and the nature of the universe to decay into chaos over time instead of growing into more and more complex systems, proves that intelligence outside of our world influenced the development of life forms and their habitat.

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[60] See for example: https://en.wikipedia.org/wiki/Creationism

[61] Eugenie Scott (13 February 2018). "The Creation/Evolution Continuum". NCSE. Retrieved 6 May 2019. Creationism comes in many forms, and not all of them reject evolution. https://en.wikipedia.org/wiki/Creationism#cite_note-5

[62] Richard F. Carlson, Tremper Longman III, Science, Creation and the Bible: Reconciling Rival Theories of Origins, p.25; https://en.wikipedia.org/wiki/Creationism#cite_note-17

[63] https://en.wikipedia.org/wiki/Creationism

They point to theories of specified complexity, irreducible complexity[64], and the law of conservation of information[65] to argue their points[66]. They imply that no such system could have come about through the gradual alteration of functioning precursor systems by means of random mutation and natural selection (as the standard evolutionary account maintains). Instead, that living organisms must have been created all at once by an intelligent designer[67].

Some of the followers of the intelligent design idea take the general view that God and creation are compatible with some of modern scientific theory, including evolution. They consider evolution as a tool used by God in His act of creation. They believe the underlying laws of nature were designed by God for a purpose, and that they are so self-sufficient that the complexity of the entire physical universe evolved from fundamental particles from processes such as stellar evolution. That life forms developed in biological evolution, and in the same way, the origin of life by natural causes has resulted from these laws[68].

Evolutionist (Darwinist) scientists reject the intelligent design idea because it assumes an exterior supernatural force is working within the development of life. The above discussions show clearly that human beliefs, even the religious ones, may change in time for better or for worse. This is why we have so many different versions of churches and religious beliefs.

IV. 1. WHAT IS THE NATURE OF GOD?

God, the creator of everything, is conceived differently by different religions and that is why so many different attributes are given to one creator. The scriptures of the Bible reveal the attributes of God.

God is independent, self-sufficient, and self-existent. He is infinite. He was never created and never came into being. He has always been. He is the great and the supreme creator from whom all has come. According to the Bible, God is-all present (Psalm 139:4-10), God is all-knowing (Psalm 139:2-4) and God is all-powerful (Jeremiah 32:17). Yet, the diversity in our culture and beliefs and the way human imagination works gives rise to very diverse interpretations.

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64 "Irreducible complexity" is the argument that says a biological system with multiple interacting parts would not function if one of those parts were removed.

65 The law of the conservation of information means that information cannot be created or destroyed as stipulated by no-cloning and no-deleting theorems of quantum mechanics.

66 https://www.compellingtruth.org/intelligent-design.html

67 https://www.britannica.com/topic/intelligent-design

68 Moritz, Albrecht (2006). "The Origin of Life". TalkOrigins Archive. Houston, TX: The TalkOrigins Foundation, Inc.

Some people perceive God as a person but with supreme qualities. Western cultures somehow assume that God is almost always an old white male[69]. It is possible that this white-old-man-in-the-heavens view could have been imprinted in their minds by the famous *Creation of Adam* painting of Michelangelo, on the roof of Sistine Chapel in Rome, Italy[70]. This painting captures the scene of God breathing life into Adam who started humanity with Eve.

Another explanation as suggested by Lesley-Anne Weir[71] is that God's depiction as an old man with a white beard is to help the human mind to comprehend something that is beyond their comprehension.

Some people assume God must be an old man because He is full of wisdom. He doesn't get sick because He is immortal, and this makes him supreme and above everything. God is often defined as infinitely merciful, just, and full of love. He can see everything; He can do anything. He blesses his devotees and rewards them with an afterlife in heaven.

God breathing life into Adam – Michelangelo's painting in Sistine Chapel, Rome, Italy.

Attributing such humanly and qualitative features to God creates confusion among His believers says Mickey Elliot (2021)[72], who explains by saying: Because such qualities can be self-contradictory, questions rise: Why a white male? Why not a female or genderless or black man? If

[69] https://news.stanford.edu/2020/01/31/consequences-perceiving-god-white-man/

[70] https://www.michelangelo.net/creation-of-adam/

[71] Quara https://www.quora.com/Is-nature-God-or-vice-versa

[72] Examining who God is according to the Bible, Mickey Elliott (09 July 2021) Special to the Reporter-Times; https://www.reporter-times.com/story/lifestyle/faith/2021/07/09/examining-who-god-according-bible/7913302002/

God is infinitely merciful, why is there so much pain and suffering around? If God loves His worshippers, what happens to those who do not worship him? There are billions of people who believe in non-Abrahamic religions like those Hindus, Buddhists, Shintoists, Jainists, pagans and many more. They worship their own gods. Abraham's God orders us not to be deceived by false gods of other religions. If that is the case, then will those billions of Hindus and Buddhists go to Christians' Hell?

Elliot further points out: "Although a God with human-like characteristics fulfils all the positives of life, this then brings negatives to the surface too. God explains the good in life, but evil remains unexplained. If God loves and cares, then why do so many people die from plagues, epidemics, cancer, and heart attacks?

The Bible, in its chapter of Genesis explains the creation of the world saying that God created this world out of nothing in a matter of six days, then had a rest the next day. This explanation creates a wrong image. It sounds like God is a person who needs a rest, like an ordinary person would after working hard for six days!

The Bible also seems to leave out a lot of information about what happened "in the beginning" - what was it before the beginning? The absence of information about the age of the planet and the creation of mankind lead to never ending speculation.

This even raises doubts about whether the words in the Bible are the words of God himself, or the words of His only son, or were these words written by some of His believers long after His son's death?

The Bible says that God created us in His image. People also question such a statement and ask that if God has created us in His image, then why does He show himself only to one prophet at a time? Why does he keep himself a secret from all of us?

In the Bible, Deuteronomy 31:6 says "Be strong and courageous, do not be afraid or terrified because of them, for the Lord your God goes with you; he will never leave you nor forsake you." Mickey Elliott[73] interprets this saying: "*He watches over us like a parent watches over a child. He loves us with unconditional love and has a good plan for our lives and wants to bless us and give us an abundant life filled with peace and love.*" But such an interpretation raises the question of why God let His only child be nailed to a cross? Abandoning your only child is not a very fatherly act,

[73] Examining who God is according to the Bible, Mickey Elliott (09 July 2021) Special to the Reporter-Times; https://www.reporter-times.com/story/lifestyle/faith/2021/07/09/examining-who-god-according-bible/7913302002/

especially while He had all the power in the universe to stop it, given He is the "*God who made the world and everything in it is the Lord of heaven and earth.*" (Acts 17:24).

When you question words written in the Bible, you may get responses like "this is what the Bible says" and "believe what it says", or "just have faith". It is not like science; you cannot go and develop another theory or another model. It seems as if God gives us a brain and then tells us not to use it. An answer that says "just have faith" really means "I don't know!" and an "I don't know" answer opens doors to alternative ideas, challenges and prepares a fertile ground for atheists and agnostics, and worse, superstition. This is another reason why there are so many diverse ideas, explanations, churches, and sub-churches.

The faithful point you to the Bible and say that every answer is in the Bible. You may not know that the Bible was written by some scholars and some words were mistranslated from Hebrew to Greek. A good example for this is mistranslation of the word "young woman of marriageable age", *almah* in Hebrew[74] to "virgin", *Parthenos* in Greek, as explained in Richard Dawkins' book *Selfish Genes* (page 270). If the word "virgin" had been intended, the correct Hebrew word to use would be *bethulah*. It is in fact the Young Woman Mary in Hebrew, not the Virgin Mary.

Beliefs evolve. While some beliefs lose their shine and vanish or fade away, others excel and gain new followers. For example, time has eroded beliefs like paganism, shamanism, voodooism, and witchcraft to give way to larger and more organised religions such as Abrahamic single God religions. Even modern beliefs like Christianity have fractionated and continue to evolve for diverse reasons. We see that the number of theologians who are strictly against scientific discoveries is declining.

IV.2. VITALISM

Before the 1800s, most people believed in "vitalism" which was often attached to religious beliefs. Vitalism is the theory that says the chemicals of living organisms are fundamentally different from those of inanimate matter[75]. At this time in history, everyone believed that living things were endowed with a special, magical property, a soul that made them living breathing objects.

According to vitalism, all living organisms contain a "vital force" that is the very essence of life. In the view of those who believe in vitalism, no substance produced by living organisms can be synthesised by combining inanimate chemicals in a lifeless container in the laboratory. To attempt

[74] https://journals.sagepub.com/doi/abs/10.1177/003463735305000105?journalCode

[75] https://science.fandom.com/wiki/Vital_Force_theory

such a task was considered a futile endeavour, due to the absence of a vital force, an enabling component (soul) which is present in all living things but absent from inanimate objects (op.cit.).

In the 18th century, it was believed that urea was a chemical of life as it can be produced only from the kidneys of a man or a dog. This belief was challenged when the German chemist Friedrich Wöhler made urea artificially by treating silver cyanate with ammonium chloride[76]. This was the first time an organic compound was artificially synthesised from inorganic materials, without the involvement of living organisms (op.cit.). The results of this experiment completely discredited vitalism. But, vitalists insisted that urea could not be made if it was not filled with the life energy of the humans and declared that this finding was still compatible with the vitalism theory.

The result was a division in beliefs. Others followed Wöhler's footsteps, and it soon became clear that the chemicals of life can all be made from other chemicals that have nothing to do with life. Although this was the end of vitalism as a scientific concept, it was extremely hard to let go of the idea because alternatives contradicted the Bible. As a result, the concept lingered around for some time.

Even scientists have struggled to shed vitalism. As late as 1913, the English biochemist Benjamin Moore was fervently attempting to revitalise the vitalism theory under another name - biotic energy[77]. It seemed there were still too many people emotionally attached to vitalism to take the next step.

Nevertheless, these changes were inevitable following the social and economic improvements and the increase in the number of educated people after the 18th century. Social and economic improvements have liberated the masses from the yolks of kings and queens and popes and clergy, although not completely, and still not everywhere. However, progress was made as the science and technology are no longer controlled by such mediaeval establishments anymore.

Darwin's theory of evolution, *On the Origin of Species* published in 1859, was the big biological breakthrough and the last nail on the coffin of vitalism. Darwin has revealed how the vast diversity of life could have arisen from a single common ancestor. Excluding plants, bacteria, viruses and fungi, the total number of individual animals on Earth adds up to approximately $20x10^{18}$, or 20 billion times billion[78]. Instead of each of these different species being created individually by God, Darwin revealed they were all descended from a primordial organism that lived millions of years ago: the last universal common ancestor (LUCA). This is known as the Biological Evolution theory.

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[76] https://en.wikipedia.org/wiki/Urea ; $AgNCO + NH_4Cl \rightarrow (NH_2)_2CO + AgCl$

[77] Michael Marshall 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

[78] Ben Team, Number of Animals on the Earth. https://animals.mom.com/number-animals-earth-3994.html

Obviously the idea came under ferocious attack, particularly from outraged Christians, but the genie was out of the bottle.

The theory of Evolution assumes that given sufficient time, the meaning of our existence could be discovered through scientific methodology. Scientists need time to get to the bottom of things to find the truth. The work of scientists generates irrefutable evidence and tangible data. The outcome of their hard work was the Biological Evolution theory.

The stance of the Vatican against the Biological Evolution theory has eventually shifted from denial to become rather positive, stating that "*scientific studies have splendidly enriched our knowledge of the age and dimensions of the cosmos, the development of life-forms and the appearance of man*"[79]. On 20 July 1969, Pope Paul VI sent blessings to the Apollo 11 astronauts who "conquered the moon" as Neil Armstrong walked on the moon. For Pope Paul VI, the moonwalk was recognition of the "greatness of God's handiwork"[80].

Roman Catholic schools started to teach evolution without controversy, on the basis that scientific knowledge does not extend beyond the physical, and that scientific truth and religious truth cannot be in conflict. This change was really an attitude of "if you can't beat them, join them". For the clergy, anything that science finds to be the probable truth about how things are, can be incorporated into religion by just saying "that's how God did it"[81].

IV.3. FEAR AND BELIEFS

Why do we believe in ideas, whether religious or not religious? The answer is because we have deep-seated fears and gaps in our knowledge. Fear makes us find a shelter or someone, an ally, a defender. We fear death, sickness, and any outside threat to our existence. It is because of this fear that human beings must anchor their beliefs somewhere to feel safe.

A threat to our existence makes us jump up or run for our life or freeze, fight, cry, or scream. Fear is the opposite of calmness and can be explained scientifically.

Our fear serves to protect us. Without fear, we wouldn't be able to survive because fear warns us about potential threats to our survival and urges us to protect ourselves from them. If we did not

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[79] Akin, Jimmy (January 2004). "Evolution and the Magisterium". This Rock. 15 (1). ISSN 1049-4561. Archived from the original on 2007-08-04. Retrieved 2014-03-14; Guntzel, Jeff Severns (March 25, 2005). "Catholic schools steer clear of antievolution bias". National Catholic Reporter. Kansas City, MO: The National Catholic Reporter Publishing Company. ISSN 0027-8939. Retrieved 2007-08-15.

[80] https://www.vaticannews.va/en/vatican-city/news/2019-07/pope-paul-vi-moon-landing-50-anniversary.html By Veronica Scarisbrick and Linda Bordoni

[81] Charles H Lineweaver, Increasingly Overlapping Magisteria. http://www.mso.anu.edu.au/~charley/papers/IncreasinglyOverlappingMagisteria9.pdf

have fear, we would be all unintentional daredevils and clumsy sods who would not survive for long. We'd be walking into oncoming trains, jumping off cliffs and wrestling with bears and tigers. The purpose of fear is to help the survival of living beings.

Fear is entrenched into all living beings during biological evolution as a mechanism for their safety. Those who feared the right things survived long enough to pass on their genes[82]. In passing on their genes, the trait of fear and the response to it was selected as beneficial to the species and entrenched into their DNA.

Fear is triggered in the human brain when we are scared. The action of being scared is detected by our five senses. Our sensory organs relay the fear to the brain, which releases a neurotransmitter called glutamate throughout the body. When glutamate rushes in your nervous system, a part of the peripheral nervous system is alarmed. This alarm will exhibit itself by making your heart race, pupils dilate, blood pressure and glucose levels increase, your breathing fast and muscles alert, or by getting goosebumps or forcing your hair to stand upright. These responses are almost entirely autonomic - involuntary bodily functions in response to the alarm raised by the autonomic nervous system.

There are checks and balances too. When we are scared, the brain sends the scary information to a section of the brain called thalamus. But, the thalamus doesn't know if the information it's receiving is a danger or not. So, it forwards the signals to the amygdala, the decision-making organ in the brain. It is the amygdala which decides if the information is really a danger or not. If it decides that it is a real threat, the amygdala then signals to the hypothalamus to go ahead and do something. The hypothalamus then immediately activates both the sympathetic nervous and the adrenal-cortical systems of the body.

The sympathetic nervous system uses nerve pathways to initiate reactions in the body, and the adrenal-cortical system pours hormones to the bloodstream (op.cit.). This speeds up bodily functions, makes your muscles tense and overall become alert. It then sends out impulses to the adrenal glands to release the stress hormones known as: adrenocorticotropic (ACT), adrenaline, noradrenaline and cortisol, into the bloodstream.

The stress hormone cortisol is the substance responsible for leading the fight or flight response, through connections with our metabolism. It influences the amount of glucose being pumped to the muscles. The ACT hormone is produced by the pituitary gland. It moves through the bloodstream

[82] https://science.howstuffworks.com/life/inside-the-mind/emotions/fear.htm

and ultimately arrives at the adrenal cortex. There it activates the release of approximately 30 different hormones that get the body prepared to deal with the threat (op.cit.).

Glucose in the bloodstream energises you to run for your life. It is the stress hormones that increases your heart rate, raises your blood pressure, makes you sweat or breathe faster, and makes you choose whether to run for your life or to stay and fight[83],[84].

Yet, there are those thrill seekers among us, the so-called "adrenaline junkies", who enjoy being afraid or maybe even showing off how brave they are to others. These are the people who love going to see horror movies, doing paragliding, rock climbing, riding roller coasters, climbing skyscrapers without safety harnesses, and participating in other scary activities.

Reactions like having goose bumps and the stiffening of hair happen because the hormone released by the adrenal gland stimulates tiny muscles to pull on the roots of our hairs, making them stand up and out from our skin. This distorts the skin and causes bumps to form[85].

Fear is simply a chemical and neurobiological phenomenon. It is common to most living beings. It is not only humans, but also animals who feel fear when they are threatened in any way, regardless of whether they are the predator or the prey[86].

When this mechanism becomes overactive and we start fearing things that are not a real threat, then it can become a source of stress, confusion, or affect our decision-making[87]. We all know that if we win or lose a lot of money when gambling that life goes on, but if someone outside puts a gun to your head and wants the money that you won at the casino, life may not go on.

Our brains are wired to respond to fear above everything else and because of this, it can become a powerful weapon - a currency, a cause of exploitation, or even used as a scamming tool in the wrong hands.

Manipulative people are very aware of this powerful weapon and try their best to control how others think and behave by artificially inducing fear. It is often used all over the world by politicians, clergy, marketers, media outlets and scammers to control masses of people.

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[83] Eduardo E. Benarroch, 2012. Periaqueductal gray - An interface for behavioral control. Neurology. 78 (3) January 16, 2012, DOI: https://doi.org/10.1212/WNL.0b013e31823fcdee

[84] Dan Wiggens, The Chemistry of Fear? 2015. https://www.reagent.co.uk/the-chemistry-of-fear/

[85] Adam Cole and Ryan Kellman, October 30, 2015. The Hair-Raising Science Of Goose Bumps https://www.npr.org/sections/health-shots/2015/10/30/452984579/why-do-we-get-goose-bumps

[86] https://www.grandin.com/inc/animals.in.translation.ch5.html Perception of fear and pain in animals; Excerpt from Chapter 5 of Animals in Translation by Temple Grandin and Catherine Johnson

[87] The Weapon of Fear: How They Use Fear to Manipulate You; https://sofoarchon.com/the-weapon-of-fear-how-they-use-fear-to-manipulate-you/

Society, our parents, teachers, and rulers all set out rules. The tax office has its own rules, prison guards make sure you follow their rules, and so on. If you don't follow their rules, they tell you that you will get into serious trouble. The clergy says that you will go to hell.

Sofo Archon[88] in reference to others expressed clearly by saying: "*Politicians often drum up reasons like terrorism, illegal immigrants, drugs pouring into the country, violence or rampant crime in your neighbourhood, to put fear into you for their own reasons"*.

People turn to religion for many reasons. Some turn to religion because it makes them content, charitable, motivated, and happy. Among those, there are some who don't find happiness in life, and so they set their hopes in an afterlife and try to find a purpose or justify their motives.

It is mainly fear that makes most humans believe in gods and religions. Religious ideas are inserted to children from childhood. In the 21st century, billions of people - over 84% of the world's population believe one form of religion or another.

Religion teaches us to follow anything the clergy imposes that is supposedly what the 2,000 years old Bible says. It teaches us to have a blind faith in the Bible, and tells us that we are potential sinners and so we should ignore our inner voice and our logic.

THE CARROT AND THE STICK

Religion promises us that God is merciful and will forgive us, even if we are serial offenders. It assures us that if we do everything the way in which it is prescribed in the Holy Book and professed by the priest, we will be rewarded with a safe passage to heaven. But if we don't, we will be punished in hell.

These concepts of fear and reward are imprinted on our minds from childhood, so that no one in his or her right mind would ever wish for punishment in hell or want to miss out on a ticket to heaven.

Belief in an afterlife optimistically is to give the living a more positive view of death. Pessimistically, it is to show that punishment will come in the afterlife if the beliefs of the religion are not strictly followed in this life. Therefore, we need to behave well and follow the commandments in the religious scripts[89].

These god-fearing beliefs were meant to make forgiving, loving, gentle, peaceful humans. But some use religion for their own interests and to preach about a vengeful, harsh, angry, punishing, unforgiving god.

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[88] Sofo Archon, Fear-Based Manipulation: How Politicians, Marketers and the Media Create Panic to Control the Masses. https://sofoarchon.com/fear-based-manipulation/

[89] https://www.psychologicalscience.org/observer/faith-or-fear; Faith or Fear? Sarah Schroeder, January 30, 2015

The question of why some of us are more naïve and gullible than the others is answered by scientists[90]. Our brains have their hindrances, and gullibility. This is one of those human handicaps. Gullibility is defined [91] as a failure of social intelligence in which a person is easily tricked or manipulated into an ill-advised course of action. It is closely related to credulity or naivety, which is the tendency to believe unlikely propositions that are unsupported by evidence.

There are hundreds of examples of gullibility listed in literature and history books. People either learn a lesson or fail to learn a lesson from their gullible experience. Ongoing internet scams in epidemic proportions around the world is another example of this.

Levitin[92] explains, "*Humans have an evolutionary tendency towards gullibility and wanting to believe what people are telling them*". Our brains are wired to make snap judgments, and those judgments can sometimes be very wrong. "*Humans have a fast-gut, quick, decision-making system that is not rational and goes with the flow, and a more slow and deliberate system. We've evolved as a species, from where the information you got from your kin-mate was reliable*" [93] . In the early days of humans, there was no way to confirm if what your friend or the tribe's elder told you was true or not. You had to take what you heard at face value.

Naivety has no limits and boundaries - it can be seen among the members of the scientific community too. This is called scientific naivety, where some scientists blindly believe what an eminent professor says and assumes it is absolutely true and correct. The difference however is that the scientific community does not order you to "*have blind faith*" about what the eminent professor says nor does it stop you from investigating further to validate or reject what was said.

Our brains also engage in a phenomenon that Levitin[94] calls belief perseverance. "*When an idea takes hold, it's hard to dislodge. When new evidence comes in, we still cling to the old belie*f." Many people lack critical thinking. Resisting these instinctive behaviours takes education and deliberate practice, says Levitin (op.cit.). "*It has to become a habit of mind.*" (op.cit.)

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[90] Daniel Levitin, 2016 It's called Weaponized Lies: Critical Thinking In The Post-Truth Era, 320 pages, ISBN-10 : 9781101983829, ISBN-13 : 978-1101983829;
Daniel J. Levitin, PhD, is a neuroscientist at McGill University Cognitive Psychologist cognitive psychologist.

[91] https://en.wikipedia.org/wiki/Gullibility

[92] Daniel Levitin, 2016 It's called Weaponized Lies: Critical Thinking In The Post-Truth Era, 320 pages, ISBN-10: 9781101983829, ISBN-13 : 978-1101983829;

[93] Parmy Olso, 2017. Why Your Brain May Be Wired To Believe Fake News. Feb 1, 2017. https://www.forbes.com/sites/parmyolson/2017/02/01/why-your-brain-may-be-wired-to-believe-fake-news/#2d266e731464

[94] Daniel Levitin, 2016 It's called Weaponized Lies: Critical Thinking In The Post-Truth Era, 320 pages, ISBN-10 : 9781101983829, ISBN-13 : 978-1101983829;

Ian Sawyer, BSc in Chemistry & Biochemistry, Aston University, England, wrote[95] to Quora and said: "*There's a correlation between religiosity and educational level, and between religiosity and fact/fiction. It seems that strongly religious people are less able to see, or at least acknowledge, the fallacies which inevitably accompany religious belief and the attempts to justify its basis.*" Sawyer also highlighted saying that "T*hese same people don't appear to have the same problem in the recognition of fallacies in other areas of their lives, only when it comes to religion. This would appear to confirm what more recent research into neuroscience has found, that there is a genetic component to religious belief which, in some people, causes a suspension of disbelief (the brain's ability to convince you that something is real, despite its implausibility) but in that belief only.*"

Sawyer thinks religious gullibility is implanted in people during their childhood. "*Religious belief is taught to children from an early age, way before they're able to discriminate between fact and fiction, and it's frequently reinforced by means of education and both societal and peer pressure. That is why there are so many Sunday schools, madrasas[96] around the world. Whilst people are younger it is understandable that they might not want to question what they're being told, however when they're older, they must surely accept that there are always two sides to a story, yet a large percentage of people who class themselves as religious, regardless of intelligence, dismiss the non-religious, scientific, version of what religion teaches, even in the face of a total lack of evidence to support their claims*" says Sawyer.

"*Is this a combination of genetics and suspension of disbelief, is it the effects of brainwashing children from an early age that such a thing as a god exists, is it fear of rejection by society if one is seen to be different (i.e., thinking for yourself!), or is it plain gullibility in adults? I suspect it's a mixture of all three*" says Sawyer.

Peter Uetz responded saying: "*Almost 40% of Americans believe in the literal story of Adam and Eve (according to multiple Gallup studies), which is nothing but mythology (given that even the pope admits that biological evolution is true[97]), and these believers are, by definition, Christians*." What makes people believe in such stories? One possible answer as suggested by Ian Sawyer could be the absence of universal healthcare and extensive social safety nets. The future uncertainties may lead them to believe in a benevolent God who will look after them. In 1927, Bertrand Russell delivered a lecture entitled "Why I am not a Christian" to the South London Branch of the National Secular

[95] https://www.quora.com/Are-religious-people-generally-more-gullible-than-non-religious-people

[96] Muslim education centres at primary school to university are often part of a mosque or a religious organisation.

[97] https://www.independent.co.uk/news/world/europe/pope-francis-declares-evolution-and-big-bang-theory-are-right-and-god-isn-t-magician-magic-wand-9822514.html Adam Withnall, Tuesday 28 October 2014. Pope Francis declares evolution and Big Bang theory are real and God is not 'a magician with a magic wand'. Pope Francis goes against Benedict XVI's apparent support for 'intelligent design' - but does hail his predecessor's 'great contribution to theology'

Society. In the lecture he said[98] "*Religious belief is a symptom of fear: aware that our lives are precarious and vulnerable, we seek the protection of a powerful deity, to comfort ourselves with an illusion of safety*." Trevor Carter pointed out[99]: "*If you want to see the gullibility of religious people, just turn your T.V. on Sunday morning. Watch a program presented by one of the mega-churches where the pastor claims to heal people. You will see thousands in attendance cheering, crying, and throwing their hands up in the air praising some invisible being for healing someone that is sick .... That's being gullible*."

It is not only blindly devoted religious people, but also scientists who could be gullible. For example, Mahdi Salehi (op.cit.) rightly pointed out the similarity between blind followers of religions and blind followers of revered scientists like Albert Einstein or Stephen Hawking.

THE PLACEBO EFFECT

People's blind beliefs may not just be due to their gullibility, but also to some extent due to part of their biochemical and psychological make-up. People devoted to a religion believe that their beliefs give them inner peace, comfort, happiness, and self-assurance. It is similar to the placebo effect, which is almost a sort of mind control over the body. Placebos (inert substances or procedures) can positively influence a person's psychological and physical well-being. This is accompanied by specific changes in their brain activity which involves complicated biochemical reactions.

Early neuro-imaging research[100] has indicated that the placebo response and religious or spiritual experiences are linked to the structure and function of neural networks, cognitive control, salience, the prefrontal cortex, insula, and the superior/posterior parietal regions of the brain.

In another study[101], both practicing Catholics and non-religious participants received noxious stimulation while they were either presented with an image of the Virgin Mary or a portrait without any religious connotation. The religious group perceived less pain while looking at the religious image when they were pricked with a needle. This was indicated from the increased activation in the ventrolateral prefrontal cortex of the brain, which plays a central role in pain modulation via

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[98] https://users.drew.edu/~jlenz/whynot.html Bertrand Russell, Why I Am Not a Christian, Watts & Co., for the Rationalist Press Association Limited, 1927 First published as a pamphlet and reissued many times since then

[99] https://www.quora.com/Are-religious-people-generally-more-gullible-than-non-religious-people

[100] Schjoedt et al., 2009; McClintock et al., 2019; Schienle et al., 2019)

[101] Wiech et al. (2008). An fMRI study measuring analgesia enhanced by religion as a belief system. PAIN Volume 139, Issue 2, 15 October 2008, Pages 467-476.
https://doi.org/10.1016/j.pain.2008.07.030 ; https://www.sciencedirect.com/science/article/abs/pii/S0304395908004211

reappraisal (op.cit.). This study concluded that religious belief might provide a framework that allows individuals to engage in what is known as pain-regulatory brain processes.

In yet another study, Schienle et al (2021)[102] investigated the placebo effect of holy (blessed) water on religious beliefs and practices. This was done by using resting-state functional connectivity and functional magnetic resonance imaging scan techniques. The study focused on the brain areas that are involved in emotional regulation, attention control, and self-awareness. In this study, the subjects were given tap water labelled "water from the sanctuary of Lourdes[103]" (which was a placebo), and "tap water" (which was the control).

The test was whether the placebo water would change the participants of the placebo group reported well-being (emotional, cognitive, bodily) and resting-state functional connectivity in their brain networks (cognitive control, salience, default-mode), when compared to the control group's participants who had received the correctly labelled tap water.

The results of the study showed that immediately after the session the participants of the placebo group who received the "Lourdes water", reported increased intensity of pleasant bodily sensations and feelings. These were described as feelings of warmth, tingling and gratefulness). The study's findings provided evidence that placebos in the context of religious beliefs and practices can change the human experience of emotional salience and cognitive control, which is accompanied by connectivity changes in the associated brain networks.

These findings are similar to the well-known placebo effect of medicating a sick person with a "dummy pill" (one that contains no active medication). For example, a positron emission tomography study [104] examined the placebo effect in the context of sufferers of Parkinson's disease. It showed that the disease itself, as well as pain and depression were related to the activation of the limbic circuitry of the brain.

The study observed that administering a placebo induced the release of dopamine in the ventral striatum of Parkinson's disease patients. Dopamine is often referred to as "the happy hormone" and the ventral striatum is the reward and emotion region of the brain. This suggests a link between the placebo effect and reward mechanisms[105]. The authors of the study suggested that the placebo-induced clinical benefits that were observed in Parkinson's disease patients was related to the

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[102] Anne Schienle , Andreas Gremsl and Albert Wabnegger. Placebo Effects in the Context of Religious Beliefs and Practices: Resting-State Functional Connectivity Study. Front. Behav. Neurosci., 06 May 2021 https://doi.org/10.3389/fnbeh.2021.653359

[103] A major Catholic pilgrimage site with reports of miracle cures.

[104] Raúl de la Fuente-Fernández, A Jon Stoessl. The biochemical bases of the placebo effect. Sci. Eng. Ethics. 2004 Jan; 10(1): 143-50. PMID: 14986780; DOI: 10.1007/s11948-004-0071-z.

[105] https://qbi.uq.edu.au/brain/brain-anatomy/limbic-system .

release of dopamine in the dorsal striatum, the movement and cognition centre of the brain, by the activation of opioid and serotonin pathways.

Opioids are addictive substances that act on opioid receptors in the brain to produce morphine-like effects. Serotonin is a small molecule (5-hydroxytryptamine) which functions as a neurotransmitter in the central nervous system and as a hormone in the periphery. Opioid receptors are involved in pain transmission and control. They are present in many regions of the nervous system including the spinal cord, midbrain, and thalamus.

Although humanity made huge progress since inventing the fire, the wheel, the telescope, the steam engine, and drastically increased our knowledge base, one could say that there is still some gullibility built in among us.

Yet there are millions if not billions of intelligent, educated people, both young and old, who go to churches, temples, synagogues and worship God and gods. They cannot all be categorised as gullible. How can we explain this? The answer again relates to the neurochemical circuits connecting the mind with the body, as well to the observance of tradition, and peer pressure.

We often say that everybody is a bit different than each other - even identical twins. This is because all humans have different genetic heritage and different learning experiences. There is always some difference, slight or strong, in our biological and neurochemical make-up and in our upbringing. Such differences can be shown through our fingerprints and our DNA. No two human fingerprints or DNA is the same. Only true clones have identical DNA but still not the same fingerprints as its host because fingerprints are not genetically but by external factors imposed on mother's womb[106].

Not only do physical traits (like eye colour, body type, or gender) differ, but so do personal traits (like levels of conscientiousness, feelings, and beliefs, levels of empathy, aggression or mildness). These differences in part relate to an individual's perception of reality, which is not the same for everyone. We can see this from the behaviour of the mentally impaired, and people under the influence of alcohol or illicit drugs. Drugs and alcohol can influence our perception of reality, although only temporarily. A person's perception of reality is influenced by a literally infinite number of variables.

Douglas Adams said: "*Everything you see or hear or experience, in any way at all, is specific to you. You create a universe by perceiving it, so everything in the universe you perceive is specific to you*[107]."

[106] http://homework.study.com/explanation/does-a-clone-have-the-same-fingerprints-as-the-host
[107] https://www.lifehack.org/articles/lifehack/your-perception-is-your-reality.html

IV.4. What Makes Humans Believe in A Supernatural Power?

You may be surprised to find out that the number of believers subscribing to the idea of a supernatural power was 5.8 billion out of the 6.9 billion people of the 2010 world's population[108]. Of the 5.8 billion, 84% represented all five major religions: Christianity, Islam, Judaism, Hinduism and Buddhism. What could be the reasons for such a high rate of devotion to religion?

Fear and the need for a protector made people flock around powerful people who declared themselves as kings and protectors of their followers. Pharaohs sold themselves as the divine intermediary between the gods and Egyptians, so that they should be worshipped. Early Romans and Greeks had scores of gods and/or goddesses[109] practically for everything, even for domestic life (referred to as household gods).

Pagans worshipped the elements of nature and considered those to be gods. This is because the natural elements affected their lives and their existence. In India, people still worship cows and elephants, rivers like Ganga, and trees like the sacred fig. Hindus believe that they get the gift of life by transforming from animals and that is why they pray to them. Native Americans hold a deep reverence for nature. They believe that all living and natural objects, as well as nonliving objects, have spirit. The Spirit found in all things is an expression of their greatness. The list of gods and goddesses of Hindus and Buddhists is rather long and they are still worshipped even today, partly because it is an established tradition.

The prevalence of early religious beliefs goes back to well before the early Egyptians, Greeks and Chinese. The earliest archaeological evidence that relates to religious beliefs dates back several thousand years, but most of the evidence from such early periods of human history is controversial. The oldest reliable archaeological evidence comes from Göbekli Tepe, a place in the southeast of present day Turkiye (Turkey), where there are circles of erected massive T-shaped stone pillars (see pictures in National Geographic[110]) that are decorated with abstract, mysterious pictograms and carved-animal reliefs[111]. The site was built before the Neolithic Era (the time of hunter-gatherers), which was before the beginning of agriculture and animal husbandry. This was around 11,000 years ago, or approximately 5,000 years before Stonehenge[112].

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[108] https://www.pbslearningmedia.org/resources/sj14-soc-religmap/world-religious-map/

[109] https://simple.wikipedia.org/wiki/List_of_Roman_gods_and_goddesses ; https://en.wikipedia.org/wiki/List_of_Greek_mythological_figures

[110] https://www.nationalgeographic.com/travel/article/150120-gobekli-tepe-oldest-monument-turkey-archaeology

[111] https://en.wikipedia.org/wiki/History_of_religion

[112] https://www.npr.org/sections/13.7/2011/10/13/141216522/the-worlds-first-temple-or-not

The nature-worshipping primitive man eventually moved on to incorporate imaginary things, superstition, and spirits into his beliefs and rituals[113]. Nature worship became a form of reverence not only to nature, but also to a place, a living being – a saint, then the cosmos, or the universe, and every other thing that a human imagination can create.

As a result, the creative minds of humans invented numerous versions of worship including theism (worshipping a creator who intervenes in the universe), deism (worshipping a creator who does not intervene in the universe), panentheism (the belief that God is greater than the universe and includes and interpenetrates it), pantheism (belief that regards the universe as a manifestation of God), polytheism (worship of more than one god), animism (worshipping a supernatural power that organises and animates the material universe), totemism (a mystical relationship with an animal or plant spirit), shamanism (interaction with a spirit world through altered states of consciousness, such as trance), paganism (pre-Christian religion, especially worshipping nature), Sarnaism (worshipping the woods), and probably many others.

As human society evolved and became more civilised, some of these idols and gods such as the ancient Roman and Greek gods and goddesses, were forgotten. Yet, some are still revered in other parts of the world. For example, the gods and goddesses of Hinduism, a major religion which is believed to have started between 2,300 B.C and 1,500 B.C[114] and has survived to the present day as a major religion followed by over one billion people.

The various forms of religion started to give comfort to the illusion-prone nature of the human mind[115]. Another motive for humans latching onto religion is to feel that they have more control over their afterlives. Death is a fundamental feature of our lives - we are born, we live, and we die. But the question of what happens to your soul - the essence that makes you a living being -when you die, has always intrigued the human mind. Humans formed religions to feel better about the great unknown after they die. It also appears that religion is just something we force onto ourselves to make sense of the meaning of life and of our own deaths[116].

The Roman Catholic Church in the early and Middle Ages (5th to 15th centuries) turned religion into a business and ripped off its faithful. The Church was more powerful and wealthy than the kings

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[113] King, Barbara J. (2007). Evolving God: A Provocative View of the Origins of Religion. New York: Doubleday Religion. ISBN 0385521553.

[114] https://www.history.com/topics/religion/hinduism

[115] https://en.wikipedia.org/wiki/Earth_religion - Boyer, Pascal (2001). Religion Explained. New Work: A Member of the Perseus Book club. pp. 1-5. ISBN 0465006965.

[116] Lewis Wolpert, 29TH JANUARY 2018. How the fear of death gave birth to religion; https://newhumanist.org.uk/articles/5282/how-the-fear-of-death-gave-birth-to-religion. a preview from the Winter 2017 edition of New Humanist. New Humanist Mind, Body & Life

and emperors. They demanded money for every service they provided - people had to pay to get married, pay to get a child baptised (if you wanted it to go to Heaven), and pay even to bury someone on their own land (if your soul wanted to go to Heaven)[117]. This made the Catholic Church extremely wealthy, while the poor with their many children[118] stayed poor. This appealed to some as a profitable business, so they created their own churches as a great tool to rule over the masses and control them.

Eventually conflicts led to fragmentation of the religions into dozens of denominations - separate churches based on their different beliefs. Sometimes this was for serious (theological) and sometimes for trivial reasons. Martin Luther, a German priest, theologian, and university professor, wanted to improve and purify the theology and practices of the Roman Catholic Church, in particular the indulgences and abuses of power by the Bishop of Rome[119]. The result was the birth of Lutheranism. Martin Luther's ideas opened the doors to the rise of the Protestant Reformation.

A good example of a trivial reason for the fragmentation of the Christian Church relates to Henry the VIII, who was the King of England in 1509 to 1547. Henry VIII decided to divorce his first wife after she had failed to produce a male heir to the throne, and he wanted to marry Anne Boleyn[120]. This required permission from the Pope based in Rome. However, the Roman Catholic faith believed in marriage for life. When the Pope did not grant the permission to divorce, Henry VIII sidelined the Pope and ordered the Archbishop of Canterbury to grant him a divorce. The Archbishop - scared for his life - granted Henry his divorce and Henry then declared himself as head of the church and made his divorce legal. In 1533, few were brave enough to tell him otherwise (op. cit.). This effectively led to the formation of the Church of England, a breakaway denomination from the Roman Catholic Church based in Rome.

Persecution also played a role. For example, when Mennonites living in Russia following 16th century Anabaptist traditions were forced to convert to the Russian Orthodox faith, they moved to Canada and other places around the world in 1786. Anabaptists originated in Switzerland but were named after the Dutch theologian Menno Simons. The Amish and the Brethren are two other splinter groups from Swiss Anabaptists like the Mennonites. The Amish came to the United States in the early 18th century also to escape persecution in Europe for their Anabaptist beliefs[121].

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[117] https://www.historylearningsite.co.uk/tudor-england/the-reformation/.
[118] Because the Bible says: God commanded his people to "Be fruitful and multiply".
[119] https://simple.wikipedia.org/wiki/Lutheranism
[120] https://www.historylearningsite.co.uk/tudor-england/the-reformation/.
[121] https://www.britannica.com/topic/Anabaptists

Religious beliefs have been evolving over time. The concepts of afterlife and resurrection have their roots go back thousands of years before Abrahamic religions. Ancient Egyptians thought pharaohs were sons of gods and when they died they would be resurrected as another god.

Zoroastrianism is one of the world's oldest single god religions which originated in present Iran. It is based on the teachings of the Avesta and the Iranian prophet Zoroaster. Zoroastrianism is messianic religion and preaches free will and judgement after death, presence of heaven, hell, angels, and demons. It may have influenced other religious and philosophical systems, including the Abrahamic religions and Gnosticism, Northern Buddhism, and Greek philosophy[122].

Ahura Mazda is referred to as the universe's supreme-being (god), an uncreated and benevolent deity of wisdom and every good thing. Zoroastrians proclaimed that Ahura Mazda was the supreme creator and the sustaining force of life. They also believed in the existence of Angra Mainyu, a destructive spirit and the adversary of all things good (op. cit.).

The rise of Zoroastrianism dates back to the 2nd millennium BCE - the Avestan period and served as the official religion of the ancient Iranian empires. When the Sasanian Empire fell in the hands of Muslims, Zoroastrianism declined to extinction. Today the Zoroastrian population is over 100,000–120,000 people which reside mainly in India, Iran, and North America (op. cit.).

Even an ordinary person now realises that the Bible is full of contradictions. For example, the four gospels were not written until some 60 years after the claimed resurrection of Jesus, and they were not written by the Apostles after which they are named[123]. The Bible appears to be a collection of 66 books, composed and compiled over 2,000 years by 40 authors on three continents[124]. For many, it became even more difficult to believe the Bible stories when they learned of the various corruptions, intricacies, power games and politics behind the splits in the Christian Churches. People soon realised that it was not God asking for faith in Him, but a beneficiary or an establishment with some ulterior motive - seeking power or money.

Apart from Zoroastrianism, Judaism is also a monotheistic religion that proclaims that there is only one God. This god was the god of the people of Israel. The idea of a single, unique God was then adopted and propagated throughout the world by Christianity and Islam. The concept and stories in

[122] https://en.wikipedia.org/wiki/Zoroastrianism
[123] https://www.quora.com/Why-are-religious-people-often-so-blind-about-their-faith?share=1
[124] https://www.biblestudytools.com/bible-study/topical-studies/when-was-the-bible-written.htm

these three religions are only slightly different[125]. The prophet of each of these religions is a descendent of the same family - the family of Abraham.

When one reads the Jewish Bible (the Torah, meaning "Teaching"), at the very beginning (in Genesis), the impression one gets is that God is the only creator of heaven and Earth. However, when examined closely, it can be seen that a plurality of gods existed in the early Middle East and Israel, and that the god of Israel was far from being the only god worshiped by the Israelites. This by itself can be interpreted as a gradual transition from the many gods to the single God concept.

The book, "*The Invention of God*," translated by Thomas Römer says (op.cit) *".... much of the contents of the Old Testament of the Bible were possibly based on accounts or stories from local empires with additional exaggerations which tended to enhance the powers of this selected god. Both the Hebrew and the Christian Bibles also have a complex history of redaction, and many of the texts we now find in these books derive not from the historical prophet in question but from more recent editors. They received their present form only in the Hellenistic period. The same observation applies to the Psalms and other texts." The word "Bible" itself derives from a Greek word 'biblia' which means books. Römer says: "No book, or more exactly no scroll, of the Bible was definitively formulated in one fell swoop. Papyrus and vellum are not durable materials and scrolls, or sheets were therefore legible only for a limited time. Their content, therefore, had to be recopied every few decades, from the end of the 7th to the 5th century, on new scrolls or sheets. Each time recopying took place it was possible to add or suppress material, or to introduce modifications in the text*".

Frans du Plessis[126] explains polytheistic origins of the God of the Bible and relates the origin to the earlier polytheist society. He says: "*As the ancient Hebrew society became more patriarchal, their beliefs gradually evolved from polytheism (worshipping more than one God), to monolatrism (acknowledging the existence of the other gods, but worshipping only one of them), then to monotheism (denying the existence of the other gods). The beliefs of Israelites became fully monotheistic following their fifty-year captivity in Babylonia, 2,500 years ago, and their exposure to Zoroastrianism, one of the oldest monotheistic religions. The Sky God El and the ancient Hebrew War God Yahweh have finally completed their merging together as the god called God/Elohim/ Yahweh. And they got rid of the other male and female goddesses*".

[125] Thomas Römer12/14/2015 The Invention of God, Translated by Raymond Geuss, ISBN 9780674504974 Harvard University Press. https://www.hup.harvard.edu/catalog.php?isbn=9780674504974

[126] https://www.quora.com/profile/Frans-du-Plessis-1

The Zoroastrians[127] had the concept of hell as a temporary place of torture, where your soul will be cleansed, after which you will join the Supreme God Ahura Mazda[128] in paradise. When the Jews adopted the concepts of heaven and hell from the Zoroastrians, they kept the concept of hell as a "*temporary supernatural washing machine*"[129]. The Christians later went totally overboard with their carrot and stick approach of supernatural incentives and disincentives, by making their hell a much scarier place (op. cit.).

The Jews also adopted, among other things, the concept of messianism from the Zoroastrians. The coming of a moshiach (messiah) was prophesied for the first time in the book of Isaiah, which was written during or shortly after their captivity in Babylonia.

In essence, Frans du Plessis says that Jewish religion, the basis of Christianity, evolved from a many gods to a single God belief gradually and over time, and not by a supernatural power and not in 6 days.

It is clear that prophets, messiahs, heaven, hell, sins, reincarnation, karma, gurus and so on, are the creations of the human mind to explain the inexplicable or to establish power over people. Atheists and agnostics think that humans created God out of their vulnerabilities, whereas the faithful claim that God created mankind in His own image (Genesis 1:26). It seems that the term 'God' means different things to different people. There is a lot of fuzziness around who God is, what Nature is, as well as equating God with Nature.

In brief, based on research and observations, humans tend to believe in a supernatural power for various reasons. Some of these reasons include:

1. Answers and comfort: Religion may give answers and a sense of belonging to some as they seek guidance in their lives and comfort during difficult times. Believing in a supernatural power brings humans psychological comfort, and reduces anxiety and fear of the unknown. It provides a sense of security and control over unpredictable situations. Some individuals have personal experiences or beliefs that lead them to embrace a specific religion. They may have had personal experiences (like a vision of Virgin Mary) that they interpret as evidence of the existence of a supernatural power, such as a miracle or a divine intervention.

2. Sense of community: Humans are social animals. Religions provide a sense of belonging to a community of individuals who share similar beliefs. According to some anthropologists, human

[127] Zoroastrianism is an ancient Persian religion that may have originated as early as 4,000 years ago and it is possibly the world's oldest and first monotheistic organised faiths still in existence. https://www.history.com/topics/religion/zoroastrianism

[128] In Hebrew the name Ahura Mazda means god or lord of wisdom, harmony, or knowledge

[129] http://www.quora.com/profile/Frans-du-Plessis-1

beings may have evolved to believe in supernatural powers as a means of survival. Believing in a higher power may have helped our ancestors cope with the challenges of life and create a sense of community and social cohesion.

3. Cultural and familial traditions: Many people are introduced to religion through their cultural or familial heritage and continue to practice it out of a sense of obligation. Our beliefs and values are often shaped by our cultural and social surroundings. Belief in a supernatural power may be influenced by a person's upbringing and the norms and values of their society.

4. Fear of the unknown: Religion provides an explanation for the mysteries of life and death, and offers hope for an afterlife. People may believe in a supernatural power to explain occurrences that seem beyond the natural world's understanding, such as death, natural disasters, and coincidences.

It is important to note that people have different reasons for believing in religions, and their motivations may vary depending on their cultural, social, and personal backgrounds.

IV.5. Beliefs Are Not Permanent – They Can Change over Time

Beliefs, like many other things, evolve and change over time. This is because beliefs are human creations and continuously questioned, corrected, and updated by other humans. A belief can be old or new, or right or wrong. The choice of right or wrong is often a personal decision. This is especially true if the belief relates to abstract subjects, such as believing in the existence of God and Soul.

If we did not question old beliefs, there would be no science, no progress, and no correct truth. Searching for the real truth is one of the greatest assets of human beings, mainly scientists.

In the old days, people believed in gods and goddesses that supposedly had super powers. They worshipped them, sacrificed sheep, cattle and in isolated cases even young boys or girls. They gave names to what made them fearful. They built their clay or wooden statues and put them in prominent places in their homes and village centres. They burned candles to please the wooden or bronze idols. These were old beliefs of pre-historic times which continued even into the ancient Roman and Greek times.

Over time, belief in multiple gods and goddesses was replaced with the single God belief. This started from the Middle East, where it seemed to be a more acceptable truth than the man made, hand carved idol gods and goddesses. Over in Asia, belief in supernatural powers of the sun and nature were replaced by Hindu and Buddhist gods and goddesses. This belief has remained intact up until the present day (with some deviations and improvements along the way).

In the Americas, the Mayas and Incas believed in a number of other supernatural beings and gave them different names. Every different geographic region of the world had its own gods and goddesses with different names, reflecting the vivid imagination of the human mind.

Things changed over time. The people living in the Americas, including the native Indians, are now mostly Catholic Christians or one or another form of Protestants (thanks to the European colonialists). When Turks lived in Central Asia over 1200 years ago, they were shamanists but are now either Muslims or Christians. Some of them adopted Islam when they moved west, from south of Caspian Sea to their present location (Anatolia), as they interacted with Muslims during that migration. Some of them became Christians when they moved north of the Caspian Sea to Europe (present day Hungary and Finland), because they encountered with Christians during their migration. Interaction with other cultures made them change their beliefs. Aborigines of Australia became Christian as part of such interactions with Christians. Religious beliefs can change over time depending on circumstances. And they will continue to change into the future.

It is also possible that an old belief can come back and become relevant again – like fashion. A good example is paganism. Before the establishment of Christianity in Europe, the dominant belief was paganism. Pagans believe in nature and recognise divinity in many forms of gods and goddesses. Most pagans believe in some form of reincarnation, viewing death as a transition within a continuing process of existence. Pagans believe that nature is sacred and human beings are seen as part of nature, along with other animals, trees, stones, plants, and everything else that is of this earth. These are very fashionable ideas today, and so paganism is now re-emerging in places like Britain and in other western countries.

Beliefs are not really God-made or given to us by an eternal power. They are man-made, and man-made things can change over time. If some Catholic schools are teaching Darwin's biological evolution theory today (even if by bending it to their way), it is a big change.

One of these changes involves the name of the creator. Starting from the 19th century, a new name was added to the list of the creator's names by scientists. This new name was Nature - the refashioned name of old animism, totemism, shamanism, and paganism or a combination of them all. Nature eventually became another name for the creator of everything, and the universe, but with a twist. This twist was that Nature (or the Universe) creates itself. Like in Buddhism, a belief in Nature does not need a divine entity to explain the origin of the universe and the creation of everything, including us. In life there will always be some supporters as well as some who are against the change (especially those making money or gaining power or something else out of those beliefs). Galileo was convicted of heresy and forced to spend the rest of his life under house arrest.

Jesus was crucified as he became a threat to old ideas and established beliefs. But then came Kepler and then Newton and multiples of other eminent scientists who showed the religious fraternity that the Earth is not flat and that beliefs evolve and change over time just like other things.

Conclusion - You decide what the meaning of your existence is – as long as you are happy with what you believe. We sincerely hope that you don't let some extremists shape your reality and inject you with false ideas and confuse your mind.

We said this because there are so many scammers, hoodwinkers, marketers, advertisers, and movies on TV channels, politicians, false pastors, and preachers and even some friends, pseudo-scientists and family members who try to make you see the things the way they want you to see them.

They use every means (legitimate or not), with good or bad intentions, ranging from simple show and tell and sweet talk, to deception and trickery. Their sole purpose is to create an impression on you, and to make their perception your reality - no matter how real it is.

These are the people inflicting pain and suffering - history books are full of them, and religious conflicts are one of them.

There are a lot of desperate people out there who need something to believe in. It's very presumptuous to try to take that away from them. Not to mention dangerous - we've seen what happens when religion is forcefully removed from a populace. Just look at Stalin's Russia or China during their cultural revolution (or was it cultural oppression?)
This author genuinely respects that people should be free to believe whatever they choose, as long as their beliefs do not harm other people. Obviously, no one – whether religious, atheist or agnostic - likes having their beliefs savagely trashed.

Next we will discuss the scientific point of view which says that Nature (or the universe) designs, puts together and operates these mind bogglingly sophisticated things that are around us everywhere. Scientists were the ones who told and proved to us that the Earth is not sitting on the back of a tortoise or an elephant, and that the Earth is not the centre of the universe. They tell us that what appears as intelligent, intricate, amazing designs and constructions does not emanate from a conscious body or mind, or from a physical entity. The Universe is not a live entity; it does not have the sophisticated cognitive abilities of humans. Nature is the creator of itself and that is what we will discuss in later chapters.

CHAPTER V: THE CONCEPT THAT SAYS BIOLOGICAL EVOLUTION HAS CREATED ALL LIVING BEINGS

Most scientists believe that if there was no biological evolution, there would be no simple and complex organisms, no plants and no animals, including us on Earth. There would be only the rocks, blowing winds, sand and soil. Even the atmosphere would be different from our oxygen rich atmosphere.

In order to host life and start the process of biological evolution, we initially need a universe with galaxies, stars, suns, and planets with land, water, and breathable air. The general scientific belief is that these requirements were provided as the result of an event called "the Big Bang" which is said to have occurred about 13.8 (or 13.7) billion years ago (see Chapter VI).

In the history of evolution of the universe, biological evolution on planet Earth has been much more recent. It is this evolution that led to the creation of life, which started around 3 billion years ago. Life on our planet did not happen overnight. The creation of life is an ongoing process. To start life, we need a suitable environment and time to materialise the right ingredients. The availability of these ingredients takes time and involves many steps, including the formation of the right geological, atmospheric and hydrospheric conditions to allow the process of biological evolution to start.

The creation of life is explained by the theory of Biological Evolution (or simply the theory of Evolution), which unravels Nature's ladder of complexity. Evolution is the step-by-step explanation of how living beings came into existence. The theory of Evolution tells us that living entities did not pop up as they are today, but evolved in a series of small steps, building upon the complexity of the previous ones[130]. The evolution theory tells us that everything started from lifeless organic molecules, which were made from lifeless but vibrating atoms. These molecules then started "*learning*" self-replication and self- autocatalysis, enveloping all their components within a membrane and making the first living cell[131].

The living cell is then divided into two, then four, then eight and so on. It grouped together to make tissues, organs, and eventually walking, talking, chirping, flying, swimming animals or plants.

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[130] https://evolution.berkeley.edu/evolibrary/article/0_0_0/origsoflife_03

[131] Witzany, Guenther (2016). "Crucial steps to life: From chemical reactions to code using agents" (PDF). BioSystems. 140: 49–57. doi:10.1016/j.biosystems.2015.12.007. PMID 26723230:
Howell, Elizabeth (8 December 2014). "How Did Life Become Complex, And Could It Happen Beyond Earth?". Astrobiology Magazine. Abiogenesis – Definition. Encyclopaedia of Astrobiology. p. 1. doi :10.1007/978-3-642-27833-4_2-4. ISBN 978-3-642-27833-4.

According to scientists, the Big Bang set the foundation for the evolution of every living being as we know today.

The theory of Evolution was formulated by Charles Darwin in his book *On the Origin of Species by Means of Natural Selection* in 1859[132]. His ideas were influenced by the French biologist Jean-Baptiste Lamarck (1744-1829)[133].

Darwin's original hypothesis has undergone extensive modification and expansion over time, especially with the advent and use of modern scientific instruments and the development of new scientific disciplines like genetics, neuroscience, and molecular biology. However, the central concepts of the theory stood firm because the theory of Biological Evolution is built upon scientific methods. This means every explanation could withstand the test of time and many new and modern testing methods. The theory of Evolution was proven to be scientifically sound, as it was based on hard and tangible evidence. As a result it has survived many counter ideas and arguments, especially those coming from religious quarters.

In brief, the Biological Evolution theory tells us that every species is related to their single common ancestor, and these common ancestors are related to each other through the very first ancestor - the LUCA (Last Universal Common Ancestor).

According to the theory, organisms will produce more offspring when there is plenty of food, space, and other resources that are essential for their survival. If a particular offspring has qualities that give it an advantage in a particular environment, then that organism will be more likely to survive and therefore pass on those traits.

As differences accumulate over generations, populations of organisms would diverge from their ancestors[134]. Biological Evolution posits that an organism can change over time because of changes in heritable physical or behavioural traits. Putting it another way, biological evolution is the change in inherited traits over successive generations in populations of organisms.

Scientific studies show that evolutionary modification of traits occur when a variation is introduced into a population by gene mutation, genetic recombination, or when is removed by natural

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[132] https://www.livescience.com/474-controversy-evolution-works.html What is Darwin's theory of Evolution? By Ker Than February 27, 2018

[133] Up until 1859, naturalist Jean- Baptiste Lamarck, believed in linear evolution, a teleological march toward greater perfection that had been in vogue since Aristotle's concept of Scala Naturae, the chain of being. https://www.scientificamerican.com/article/darwins-influence-on-modern-thought1/

[134] Evidence Supporting Biological Evolution. https://www.ncbi.nlm.nih.gov/books/NBK230201/

selection or genetic drift. Adaptation is a key evolutionary process in which traits and species are adjusted by natural selection, to become better suited for survival in specific habitats[135].

Supporting evidence for biological evolution comes from palaeontology – fossil records, comparative anatomy, biogeography, embryology, genetics, and molecular biology[136].

V.1. Evidence from Fossil Records

Fossils are found in sedimentary and slightly metamorphosed sedimentary rocks that form layer upon layer. These layers may contain minerals that can be dated using radiometric methods The age-dating methods help scientists determine when an organism lived on the scale of geological time.

Radiometric age is determined in places where a fossil is found in association with certain minerals, such as carbon, zircon or strontium. For example, scientists can use radiometric aging to assert that trilobites, a group of extinct marine arthropods, first appeared on earth around 521 million years ago during Cambrian time[137].

Fossil findings provide a huge body of evidence for systemic changes over time. They predict that no reversals will be found in future paleontological studies. This means "*Mammals will not appear before reptiles, and no complex life will occur in the geological record before the oldest eukaryotic cells*" (op.cit.. So far, no contrary evidence has been found to override this finding.

V.2. Evidence from Comparative anatomy

Comparative anatomy is the study of similarities and differences in the anatomy of different species. It provides valuable evidence in support of the common descent concept and has also assisted in animal classification studies[138]. A common example is the comparison of the forelimbs of vertebrates, where the wings of bats and birds, a mouse's forelimb, a human arm, the front flippers of whales, and the forelegs of dogs and crocodiles have the same basic components - as they are all derived from a common four-limbed vertebrate ancestor[139]. Another example is provided by Dartmouth researchers[140] who report that apes and early humans evolved more flexible shoulders and elbows than monkeys, so that they could safely come down from trees. According to this study,

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[135] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/biological-evolution

[136] Evidence Supporting Biological Evolution. https://www.ncbi.nlm.nih.gov/books/NBK230201/

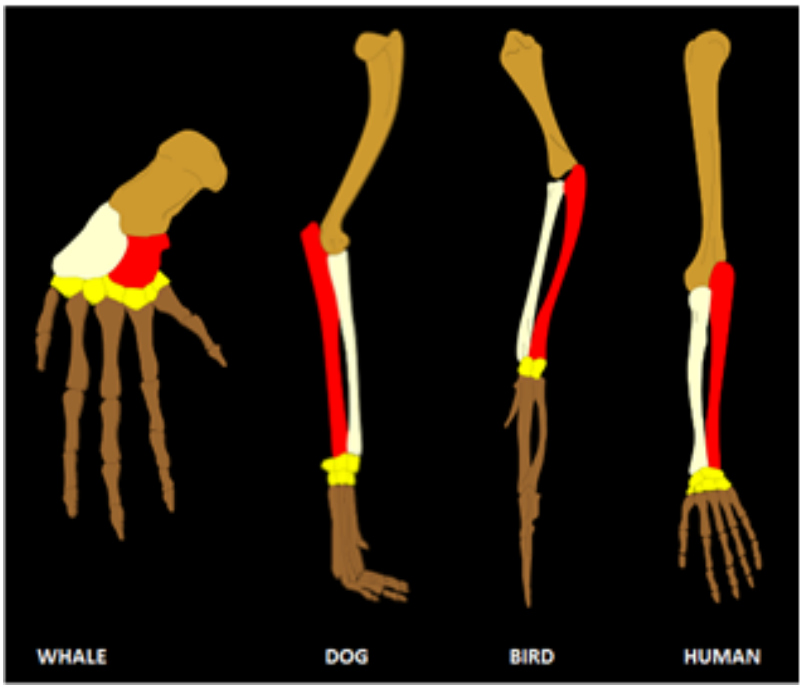
[137] https://oumnh.ox.ac.uk/learn-what-were-trilobites

[138] https://en.wikipedia.org/wiki/Comparative_anatomy

[139] Evidence Supporting Biological Evolution. https://www.ncbi.nlm.nih.gov/books/NBK230201/

[140] Dartmouth College (2023). Downclimbing and the evolution of ape forelimb morphologies, Royal Society Open Science (2023). DOI: 10.1098/rsos.230145. royalsocietypublishing.org/doi/10.1098/rsos.230145 https://phys.org/news/2023-09-human-shoulders-elbows-evolved-climbing.html

when early humans left forests for the grassy savannah, they needed versatile appendages for gathering food and deploying tools for hunting and defence. The Dartmouth researchers point out that it is that same early ape forelimb anatomy with a couple of tweaks. They say *"we're modified, but the hallmarks of our ape ancestry remain in our modern skeletons"*.



The biological relationships (shown by colours) of the bones in the upper limb of various vertebrates were used by Charles Darwin as an argument in favour of evolution. Source: Wikipedia.

V.3. EVIDENCE FROM BIOGEOGRAPHY

Biogeography also provides evidence in support of the descent from common ancestors. Some species, such as human beings, can live under a wide range of environments, yet others are strictly localised. Humans and migrating birds historically are one of the most mobile species that have spread around the world. When organisms migrate from one place to another, their genes are also transferred from one population to another – a process known as gene flow[141].

A variety of human races have evolved through the process of gene flow. Genghis Khan, the fearsome Mongolian warrior of the 13th century, is one of the best examples. An international group of geneticists studying Y-chromosome data in 2003 have found that nearly 0.5 percent of the

[141] https://www.livescience.com/474-controversy-evolution-works.html What is Darwin's theory of Evolution? By Ker Than February 27, 2018

male population in the world - or roughly 16 million people[142] - carry the genes of Genghis Khan and are therefore descended from him[143].

Historically, ships have contributed to the wider biogeographic distribution of various species to the remotest of islands. For example, there were no mammals other than one bat species living in the Hawaiian Islands before the first human settlers arrived[144].

Besides man-made factors, there are many other means which contribute to the geographic distribution of species. Among them are climatic factors such as water availability, sunlight, atmosphere, humidity, temperature, salinity, acidity (pH), disease, and competition for resources such as food, water, and mates can all affect how a species is distributed. For example, most species will gather around water sources, forming a clumped biogeographic distribution (op.cit..).

V.4. Evidence from Molecular Biology

The unifying principle of common descent that emerges from all the foregoing lines of evidence is being reinforced more recently by the discoveries of modern biochemistry and molecular biology. Molecular biology is a branch of biology that deals with the structure and function of macromolecules (such as proteins and nucleic acids) which are essential to life.

A good example of molecular biology is the evolution of eyes[145]. Eyes may have evolved independently many times before becoming a human eye. Eyes' evolution started from simple light-sensitive reticular cells, like those found in the present-day flatworm. Those cells then evolved to form individual photoreceptor cells, and then the compound eyes of arthropods like insects, crustaceans and millipedes. These contain a cluster of photoreceptor cells surrounded by support cells and pigment cells, and then developed into the eventual formation of the human eye, with a single lens focusing images onto a retina (op.cit..).

The eyes of humans and other vertebrates consist not only of photoreceptor cells, but also of several types of neurons that begin to analyse the visual image. Through such gradual steps, different kinds of eyes have evolved over many millions of years from simple light-sensing organs that can detect light, to overly complex systems for vision (op.cit..).

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[142] The population of the world in 2003 was 6.314 billion. https://study.com/academy/answer/the-population-of-the-world-in-2003

[143] Hillary Mayell, February 14, 2003. Genghis Khan a Prolific Lover, DNA Data Implies. https://www.nationalgeographic.com/culture/article/mongolia-genghis-khan-dna

[144] https://en.wikipedia.org/wiki/Species_distribution

[145] Evidence Supporting Biological Evolution. https://www.ncbi.nlm.nih.gov/books/NBK230201/

Other biological evidence[146] relates to European mice that were brought to Madeira Island in the Atlantic Ocean (520 km to the west of the Kingdom of Morocco), by Portuguese explorers in 1419. These mice have now evolved into at least six different species. The island is very rocky, and the mice became isolated into different niches. The original species had 40 chromosomes, but the new populations have between 22-30 chromosomes. They haven't lost DNA, but rather, some chromosomes have fused together over time and so the mice can now only breed with others who have the same number of chromosomes as them, making each group a separate species (op. cit.).

It appears that a group of species moved to a different environment will go on evolving until they are too genetically different to interbreed.

Another remarkable example is the London Underground mosquito, (op. cit.) which is believed to have evolved from an above-ground mosquito species following the construction of the London underground rail system in the 1850's. Today, the underground mosquito's aggressive bite gives commuters hell, while the above-ground species only feeds off birds. The two species can no longer interbreed and have become separate in just 170 years.

The developmental characteristics of a particular species are normally quite stable, even in places where the environmental conditions fluctuate. But if the environmental conditions are pushed beyond the normal variability, previously inactive genes and other genetic variation that is usually hidden may be switched on, to trigger a rapid evolution (op. cit.).

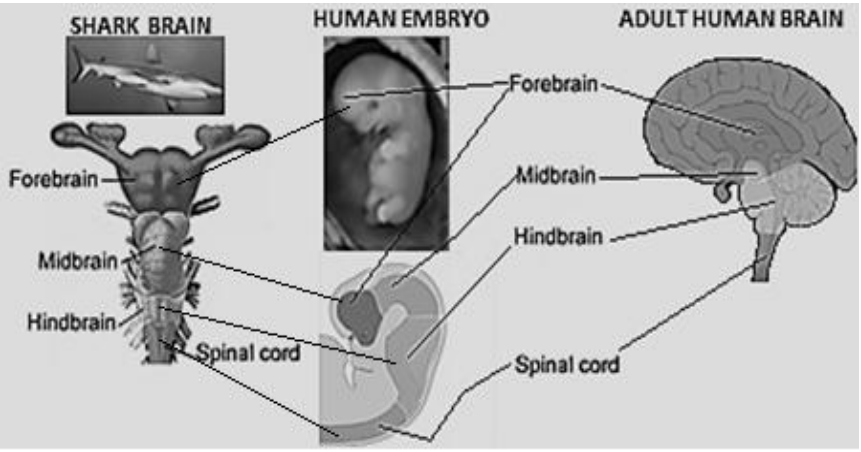
V.5. Evidence from Embryology and Genetics

Embryology - the study of biological development from the time of conception - is another source of independent evidence for common descent. A wide variety of organisms, from fruit flies to worms to mice to humans, have similar sequences of genes. The presence of such similar genes doing similar things across such a wide range of organisms is best explained by all these groups having an early common ancestor[147].

Another example is the same four-compartment brain structure of all animals, including humans.[148] The four compartments are the spinal cord, the hindbrain, the midbrain and the forebrain. Even though a shark's brain is primitive, it still consists of these four compartments - just like brains of humans.

[146] https://www.abc.net.au/science/articles/2010/03/10/2820949.htm
[147] Evidence Supporting Biological Evolution. https://www.ncbi.nlm.nih.gov/books/NBK230201/
[148] Bozeman Science, The Brain, https://www.youtube.com/watch?v=kMKc8nfPATI

In all animals, each of these compartments functions the same way. The spinal cord brings information in. The hindbrain coordinates vital bodily functions - such as keeping the heart beating, blood circulating, breathing, and digestion. The midbrain is for vision, hearing, motor control, sleep, and wakefulness (op.cit..). Forebrain is for planning and execution of movement, sensory processing, regulating sleep and behavioural responses like stress and fear. Each of these can have an impact on breathing[149].



The brains of animals, whether a shark, a human baby in the womb or a human adult, are made of four major compartments.

Biologists define evolution as genetic change in a population across generations. The process of genetic change in the genetic code or DNA gives rise to new genes, new traits, and new species.[150] It is these changes in a population which give rise to genetic diversity. The variation of genes within a population is the cornerstone of biological evolution and makes populations healthier. The more diverse the genes in a population, the more likely it is that one of those genes will prove helpful for adapting to changing environmental conditions, such as climate change or a new disease[151].

Every living being is a complex chemical factory. Like every other factory, stuff comes in, gets processed and unwanted stuff and any residue comes out. If this factory is exposed to a change in the quality of the feedstock, or to an undesirable element or chemicals, or high doses of gamma or X-ray radiation, the routine function of one or more parts of this factory will be affected. The effect could be favourable or adverse. The product that is supposed to come out of the sector could be different from the product that routinely comes out, or even defective.

[149] https://www.ncbi.nim.nih.gov/pmc/articles/PMC9663927/
[150] https://sciencing.com/describe-process-artificial-selection-16957.html
[151] https://sciencing.com/examples-genetic-diversity-16445.html

In the case of human beings, genetic abnormalities may be present and if these abnormalities are transferred to offspring, this could be an impediment to biological evolution or may drive biological evolution forward in a beneficial way.

Genetic diversity is affected largely by gene-shuffling (crossing over), mutations and inbreeding, and these items are discussed in the following subsections.

V.5.A. GENE-SHUFFLING (CROSSOVERS)

DNA exchanges, also called crossovers, are essential for generating genetic diversity - the driving force for evolution[152]. Crossing over happens during meiosis, a cellular process where a cell divides in two, resulting in an egg or sperm. When sex cells are produced, chromosomes exchange large segments of DNA. It is this process that gives each new cell a unique genetic makeup.

Scientific work has shown that the cellular mechanism that determines where and how many DNA exchanges would form, is not a mystery anymore. We now know that a protein called HEI10 plays a major role in crossover formation in meiosis (op.cit..). This process takes place when small HEI10 proteins cluster along chromosomes, triggering homologous recombination (or the shuffling of genes). This results in an increase in the genetic diversity of a population during meiosis (cell division)[153].

When two chromosomes swap genes during meiosis, the resulting chromosome is different. These exchanges, or crossovers, make the offspring a little different from their parents which drive biological evolution. Such exchanges help evolution go forward only if it is done just right – too much crossing over is stressful to the chromosome, and too little doesn't create enough diversity (op.cit..).

Gene-shuffling happens in nature all the time. For example, Guilherme Gainett et al, (2021)[154] has shown that a short leg daddy-long-leg spider (*Phalangium opiliones*) can be made in a laboratory, simply by tweaking a couple of their genes. The researchers identified two genes involved with leg

[152] https://phys.org/news/2021-08-sex-cells-genetic-interdisciplinary-approach.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter
Diffusion-mediated HEI10 coarsening can explain meiotic crossover positioning in Arabidopsis, Nature Communications (2021). DOI: 10.1038/s41467-021-24827-w

[153] Crossing over: How are genes shuffled? By Deborah Devis, https://cosmosmagazine.com/science/biology/crossing-over-protein-shuffles-genes-during-meiosis/

[154] Guilherme Gainett et al, (2021). The genome of a daddy-long-legs illuminates the evolution of arachnid appendages, Proceedings of the Royal Society B: Biological Sciences (2021). DOI: 10.1098/rspb.2021.1168

development. Using RNA (ribonucleic acid) interference, when they blocked the activation of these genes, they saw daddy-long-leg spider then grew up with short legs[155].

A common example of creating genetic diversity is in the domestication of dogs. Humans have created many new breeds of dogs, by selectively breeding dogs with traits that they want. This human-imposed genetic shuffling (by controlling dogs' access to mates) has created a dog population that has more genetic diversity than the wolf, their closest wild cousin[156]. Since the 1940s, studies in canine genetics have consistently shown that traits such as fearfulness, impulsivity, problem-solving ability, working drive, and even tendencies toward aggression, are strongly influenced by breeding[157]. Non-aggressive dog progeny could be bred by selectively mating good-natured male and female dogs.

Yet another commonly known example of man-made genetic diversity is genetically modified (GM) foods like rice, corn, potato, cotton, canola, etc. GM foods are produced by agriculturists, by making changes to their DNA using genetic engineering methods.

V.5.B. MUTATIONS

Mutations can result when mistakes are made in DNA copying during cell division. They can also occur due to exposure to ionising radiation or mutagen chemicals or even by infection by viruses[158]. Mutations can be a germinal type (which occurs in eggs and sperm) and can be passed onto offspring, or a somatic type (which occurs in cells of the body and are not passed onto offspring)[159]. Putting it another way - somatic mutations are not transmitted to progeny, but germinal mutations may be transmitted to some or all progenies.

Somatic mutations are frequently caused by environmental factors, such as exposure to ultraviolet radiation or to certain chemicals[160]. A germinal mutation occurs in the germ line - special tissue that is set aside in the course of development to form sex cells. If a mutant sex cell participates in fertilisation, then the mutation will be passed on to the next generation. The haemophilia mutation

[155] Genetically altered daddy longlegs have short legs, by Bob Yirka , Phys.org https://phys.org/news/2021-08-genetically-daddy-longlegs-short-legs.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

[156] https://sciencing.com/examples-genetic-diversity-16445.html

[157] https://www.drjensdogblog.com/its-not-all-in-how-you-raise-them-the-role-of-genetics-in-behavior/

[158] https://sites.google.com/site/scbiopt2014mutations/home

[159] https://www.genome.gov/genetics-glossary/Mutation

[160] https://www.britannica.com/science/somatic-mutation

in European royal families is thought to have arisen in the germ cells of Queen Victoria or one of her parents. The mutation was expressed only in her male descendants[161].

Cells replicate their DNA when they divide. The DNA codes of the product cells are identical copies of the original cell; these are known as daughter cells. Sometimes the cell's DNA replication machinery makes errors, so that one or both daughter cells have an altered copy of the original code[162]. Mutation can take place anywhere and anytime. The majority of mutations that make an impact in evolution resulted from an imperfect copy of DNA.

Mutations in DNA create genetic diversity in a population (op. cit.). Over time, mutations and sexual reproduction ensure that organisms are not all genetically identical - even when they are descended from the same ancestors. If you compare DNA from different organisms in the population, you'll usually find many subtle differences.

A chemical or sunlight damage causes random errors in DNA replication. Chemical changes in the environment alter some DNA nucleotides by producing different hydrogen bonds. Ultraviolet (UV) energy from sunlight mutates DNA by causing the formation of unnatural links within the DNA, which are then carried to new cells. A radioactive material can give off alpha, beta, gamma and X-ray radiation, which may be absorbed by water molecules of the cell. This water molecule then transforms into a reactive free radical, which attacks the DNA molecule (op.cit..).

Mutations can be harmful, neutral or beneficial. When DNA is mutated, it changes the protein sequence and creates either functional or non-functional proteins. Some mutations are generally harmless and are created over a few generations, causing them to be passed down from one family generation to another. Scientists have shown through studies that we will have between 100 to 200 mutated genes in our lifetime, either by hereditary or environmental influence[163].

If a mutation proves to be beneficial to the organism, it will become more prevalent in the next generation and spread throughout the population[164]. A mutation is considered to be beneficial if it increases the chance of survival or the chance of withstanding certain conditions of the mutated organism. It may allow the organism to reproduce more quickly and have a higher population in a changing environment, because of natural selection.

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[161] https://www.ncbi.nlm.nih.gov/books/NBK21894/ Griffiths AJF, Miller JH, Suzuki DT, et al. 2000. An Introduction to Genetic Analysis. 7th edition. New York: W. H. Freeman and Company.

[162] https://sciencing.com/relationship-between-dna-natural-selection-2027.html

[163] https://sites.google.com/site/scbiopt2014mutations/effects-of-mutations

[164] What is Darwin's theory of Evolution? By Ker Than February 27, 2018; https://www.livescience.com/474-controversy-evolution-works.html

An interesting example of a beneficial mutation is the genetics of the sickle cell trait. Normally, a sickle cell causes anaemia and exhibits painful symptoms. However this mutation, found in one-third of the population of Sub-Saharan Africa[165], gives those with the mutation immunity against the malaria disease in an area of the world where this disease is common. A detailed discussion on "Sickle Cell Haemoglobin and Malaria" can be found in Bufford (2004)[166], which suggests that malaria has produced an environment selective for the mutation of sickle cell haemoglobin and created inheritance patterns that allow it to be passed through generations.

Viruses can induce gene mutations when a "spike" protein on the viral surface (like COVID-19) attaches to a target cell receptor in a foreign body. Once attached, the virus hijacks the cell's genetic machinery to copy itself. Once in, the virus does not sit idle in the host cell. Rather, it adapts to the changes taking place in that new setting and starts mutating. Mutation can also occur when an error is incorporated into the viral genome. This type of mutation is known as a virus induced gene mutation. Viruses continuously change because of genetic selection. They undergo subtle genetic changes through mutation, so that rearrangements in the genome only occur on a small scale. Viruses can also undergo a major genetic change through recombination, which causes a large-scale rearrangement in the genome.

During the writing of this book, the world was grappling with the COVID-19 (SARS-CoV-2) virus pandemic. It was claiming human lives nearly in every country, and more scaringly, the virus was evolving and mutating, forming new and more infectious hybrid variants[167]. These mutations were happening within a short period of time and right before our very eyes. In May 2021, four corona virus variants of global concern were identified by the World Health Organization (WHO). These variants were first detected in the UK, South Africa, Brazil, and India then later spread around the world, killing millions of people.

Current mRNA vaccines (like those of Moderna and Pfizer-BioNTech) encrypt a viral protein (amino acid) to provoke an immune response. These vaccines were largely protective against the delta variant which swept through unvaccinated populations around the world starting from June-July 2021. Scientists are concerned that other variants may emerge that are more virulent and

[165] https://sites.google.com/site/scbiopt2014mutations/effects-of-mutations

[166] Julie Ann Buford, 2004. Sickle Cell Haemoglobin and Malaria: An Adaptive Study of Natural Selection on an Infectious Disease. http://www.anthropology.ua.edu/bindon/ant475/Papers/Buford.pdf

[167] What makes some COVID-19 variants more contagious than others? ABC Health & Wellbeing, By science reporter Gemma Conroy, Posted 2/6/2021. https://www.abc.net.au/news/health/2021-06-02/what-makes-some-covid-variants-more-contagious-than-others/100179418?utm_

transmissible - even among those already vaccinated, however, so far this did not happen by the time this book went for publication[168].

Chemicals can cause mutations: It is well established that some chemicals, called teratogens, can cause mutations. Teratogens can be found naturally in the environment, or in man-made stuff such as some forms of medicine, biological warfare agents, illicit drugs, tobacco products and those containing chemicals like aromatic amines, nitrosamines, cyanide, arsenic, carbon monoxide, dioxin, and alcohol[169].

An example of a man-made mutagen is Agent Orange, which is a nerve gas that was used during the Vietnam War (1955 – 1975). Agent Orange is a dioxin (2,3,7,8-tetrachlorodibenzo p dioxin or TCDD), a fat-soluble chemical, and causes cancer and birth defects[170]. Dioxins can enter the body through physical contact, inhalation, or ingestion of smoked food such as ham, sausage, fish, and meat. Dioxins accumulate in organisms. When a pregnant mother is exposed to a dioxin, a teratogenic agent[171], can enter the embryo via the mother's bloodstream. Dioxins are taken up by the body by attaching to the protein aryl hydrocarbon receptors (AhR). When dioxin binds to AhR, the protein moves to the nucleus of the cell where it influences the timing and levels of gene expression. This leads to birth defects (op.cit..). Accumulated exposure to dioxin causes prostate cancer in older men[172].

After the Vietnam War, high rates of miscarriages, premature births, congenital birth defects, and infant mortality began to emerge from regions of Vietnam where Agent Orange was used. Agent Orange caused neural tube defects among the children of the war veterans, by either mutating a gene or a chromosome of the sperm before fertilisation, or by the transmission of dioxin with the sperm[173].

V.5.C. Radiation Related Mutation

Mutations can also result from exposure to ionising radiation including alpha, beta, gamma rays, X-rays, fast neutrons, and nuclear fission products. The radiation could be either man-made or natural (known as background radiation). Background radiation is mostly from rocks and minerals containing the potassium-40 isotope. Alpha radiation can come from or be emitted from granitic

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[168] Elaine C. Chen et al, Convergent antibody responses to the SARS-CoV-2 spike protein in convalescent and vaccinated individuals, Cell Reports (2021). DOI: 10.1016/j.celrep.2021.109604

[169] https://www.osmosis.org/answers/teratogen

[170] https://sites.google.com/site/scbiopt2014mutations/agent-orange/how-agent-orange-affected-the-genes

[171] Teratogenic agents cause developmental malfunctions.

[172] https://pubmed.ncbi.nlm.nih.gov/24461260/

[173] https://sites.google.com/site/scbiopt2014mutations/effects-of-mutations

rocks which contain minerals, such as slightly radioactive zircon as well as those which contain strongly radioactive minerals like monazite or uraninite.

Norway is one of the most alpha-emitting radium and radon (gas) terrains in Europe. Radium and radon are radioactive decay products of uranium and thorium minerals found mostly in acidic granitic and pegmatitic rocks. Based on a study,[174] 9% of houses in Norway have an annual mean radon concentration exceeding the recommended action level of 200 Bq/m^3. Very high radon concentrations (50,000 Bq/m^3) have been recorded in poorly ventilated cellars of houses located on permeable sediments covering granitic rocks. Man-made radiation is mostly what we are exposed to at the dentist, or during a CT scan or chemotherapy. White ceramic toilet seats and wall tiles are also slightly radioactive as they contain zircon, which is the mineral that makes the glazed appliances white and shiny[175].

Among the variety of radiations, fast neutrons have been found to be up to about 100 times more mutagenic (causing mutations) than X-rays. Radiation causes destruction to the cells and aberrations to chromosomes. Only a small percentage of all chromosomal aberrations is attributable to natural background radiation - the majority result from other causes, including radiotherapy equipment in hospitals, leaks from nuclear power stations, certain viruses, chemicals, and drugs.

On September 13, 1987, in the Brazilian state of Goias, in the Goiania district, a radiation related incident resulted in 4 deaths and the contamination of 249 people. In this case, the radioactive material was the cesium-137 isotope used in the radiotherapy machines, which was stolen from an abandoned hospital site in the city[176]. Anyone who touched this had radiation sickness problems, such as burns, vomiting, and amputations that were mainly due to the destruction of their red and white blood cells.

Radiation breaks both the DNA strands and the chromosome fibres. It interferes with the normal segregation of chromosomes at the time of cell division (mitosis), thereby altering the structure and number of chromosomes in the cell[177]. Chromosomal changes of this kind may cause the affected cell to die when it attempts to divide, or they may alter its properties in various other ways [(op.cit..)]. Chromosome breaks often heal spontaneously, but a break that fails to heal may cause a loss of

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[174] Terje Strand et al., 2005. High radon areas in Norway. International Congress Series. Volume 1276, February 2005, Pages 212-214. https://doi.org/10.1016/j.ics.2004.10.027

[175] In zircon, the alpha radiation emitted by the radon gas is a decay product of radium. However, this gas is mostly absorbed by the borosilicate glaze so that it does not cause a health problem. R S O'Brien et.al., 1998. Radon exhalation rates and gamma doses from ceramic tiles. Health Phys 75(6):630-9. PMID: 9827510, DOI: 10.1097/00004032-199812000-00007

[176] https://en.wikipedia.org/wiki/Goiania_accident

[177] https://www.britannica.com/science/radiation/Damage-to-genes-mutations

genetic material. When in one nucleus adjoining chromosome fibres are broken, the broken ends may join in such a way that the sequence of genes on the chromosomes is changed (op.cit..).

V.5.D. INBREEDING

Inbreeding, or incestuous sexual relationships, could be responsible for reversals in biological evolution (devolution). Namely, the reappearance of an ancestral genetic trait that was lost through evolutionary change in previous generations[178]. Inbreeding and consanguinity (blood relationship) removes genetic diversity and leads to the rise of deleterious or recessive traits or increased genetic disorders[179]. In humans, these disorders appear as decreased biological fitness, a less robust population in terms of reduced fertility, lower birth rates, higher child mortality, higher cardiovascular risks, smaller adult size, facial malformations, and in rare cases loss of bipedality and the appearance of a hairy face and a tail[180].

Inbreeding in the present Middle East, especially among cousins, is a tradition which has its roots in ancient Egypt and Mesopotamia. For example in ancient Egypt, royal women were believed to carry the royal bloodline and so it was advantageous for a pharaoh to marry his own sister or half-sister. All rulers of the Egyptian Ptolemaic dynasty, uninterruptedly, were married to their own brothers and sisters, so as to keep the Ptolemaic blood "pure" and to preserve the line of succession.

Royal intermarriage was often practised among European royal families and many European royalties are blood related. Such intermarriage creates a progressively smaller gene pool, as the number of potential royal consorts is relatively limited.

Many members of royal families are descended from a certain person through many lines of descent. For example, numerous members of European royalty and nobility are descended from the British Queen Victoria or King Christian IX of Denmark.

Other well-known examples of incestuous marriages include the houses of Habsburg, Bourbon, Braganza and Wittelsbach where first-cousin unions, as well as the occasional double-cousin and uncle–niece marriage, were frequently observed (op.cit..). In the last Spanish Habsburg family, Charles II of Spain (1661-1700) could not properly chew his food. He also had many genetic, physical, intellectual, sexual, and emotional problems. His brother–sister incest resulted in impotence, which led to the extinction of the male Spanish Habsburgs (op.cit..).

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[178] Inbreeding is the production of offspring from the mating of individuals that are closely related genetically. Inbreeding causes genetic disorders and other deleterious or recessive traits. https://en.wikipedia.org/wiki/Inbreeding

[179] the sexual activity between family members or close relatives

[180] https://en.wikipedia.org/wiki/Inbreeding

Inbreeding can also cause other bizarre facial and bodily malformations. One of them is the occasional appearance of people with so-called Uner Tan Syndrome which results in an ape-like head with a human body. Tan[181] reports a 70-month old baby with a protruding jaw and face, flat skull, flat head, with low-set ears and flapped ear flaps, but a human-like body with normal arms and legs. This baby also had exophthalmic eyes (where the eyeballs protrude from the eye socket) making them appear to bulge, broad shoulders, a short neck, thick arms, was quadrupedal and had primitive cognitive abilities. The jaw and face are markedly protruded, a more severe prognathism of Habsburg Jaw. The baby also had a very small brain, known as microcephaly, where the posterior part of the brain is underdeveloped. The lower jaw was prognathic - projected forward especially to an unusual degree.(op. cit.).

A study published in the *American Journal of Human Genetics* [182] explains what causes this abnormally small brain, speech delay and ectodermal dysplasia - an inborn condition that affects hair, nails, teeth and skin. According to the researchers, a gene called ZNRF3 was responsible when they sequenced part of the DNA of 11 of their patients.

Charles II of Spain's Habsburg jaw; a severe type of face malformation, mandibular prognathism. Pathologic mandibular prognathism is a genetic disorder where the lower jaw outgrows the upper, resulting in an extended chin and a cross bite. It can also be seen in animals, for example, flat-faced boxer dogs, and it is the result of inbreeding.

[181] Tan, Uner, 2008. - A Special Case of Anencephaly in an Early-Born Baby with an Exaggerated Prognostic Face: Further Example for Human Devolution. The International journal of neuroscience. 118, 60, 751. DO - 10.1080/00207450701668004

[182] Paranchai Boonsawat et al, Deleterious ZNRF3 germline variants cause neurodevelopmental disorders with mirror brain phenotypes via domain-specific effects on Wnt/β-catenin signaling, *The American Journal of Human Genetics* (2024). DOI: 10.1016/j.ajhg.2024.07.016

They found the responsible defect was in one of the copies of the gene ZNRF3. Apparently, this defect leads to the production of a harmful protein. They explained: "*The human brain relies on two copies of this gene to build a correctly sized brain. If one of the copies is defective, the brain will be too small or too large - known as mirror effect - leading to various neurological symptoms*".

Bipedalism - walking on two feet, is a distinct feature that makes humans differ from most other animals. Yet, occasionally people are found with quadruplicity, namely walking on their arms and legs like most four legged animals do. Early humans are known to have walked on their arms and legs just like animals. Human bipedalism started 6 million years ago, originating in East African coastal forests, but how our standing posture evolved is still a great mystery.

A newborn human baby and most toddlers are often not bipedal until they reach the age of 6 to 12 months old. They are crawlers, [183] like many other animals. Babies crawl on their arms and knees, or on their belly like a commando soldier, or on their arms and legs like a bear or a monkey, or even sideways like a crab. Some crawl so-called bum-shuffling. This can be seen as one of the best reminders of our evolutionary history. Walking on arms and legs and crawling indicates the transition from primitive human to Homo erectus and then to Homo sapiens - the modern human.

There are some theories[184] about what made humans switch to bipedalism. The general belief is that the desire to reach for and carry food might have contributed to the emergence of the early hominids' ability to stand up and walk. We can see this from toddlers, when they want to reach for an attractive toy and carry it around with them. We also know that infants cannot walk to the toy before they learn to maintain their body weight, to keep balance on one leg while the other leg swings forward. This needs practice - trials and errors teach them to strengthen their legs. Holding on to furniture teaches them how to control their balance and stand up to a vertical position. Infants learn how to walk often by holding onto furniture and holding their parents' hand[185].

One example of quadruplicity mentioned in literature comes from a family who lived in south-eastern Turkiye (Turkey)[186]. This family had 19 children, but 5 of them had quadruplicity. One affected sibling died at the age of 26 of unknown causes. The living quadruped ones were 3 young

[183] Although some babies opt not to crawl at al – they go straight to standing, cruising, and walking.

[184] Lana B. Karasik, Catherine S. Tamis-LeMonda, and Karen E. Adolph (2011). Transition from Crawling to Walking and Infants' Actions with Objects and People. Child Dev. 2011 July ; 82(4): 1199–1209. doi:10.1111/j.1467-8624.2011.01595.x.

[185] Karen E. Adolph, Sarah E. Berger and Andrew J. Leo 2011. Developmental Continuity? Crawling, Cruising, and Walking. Dev Sci. 2011 Mar; 14(2): 306–318. DOI: 10.1111/j.1467-7687.2010.00981.x

[186] https://europepmc.org/backend/ptpmcrender.fcgi?accid=PMC2564522&blobtype=pdf

women, aged between 18 to 34 years old (in 2006), and one 28-year old man, who had been walking on their hands and feet since they were children.

One of the distinct features of humans is their bipedality. However, among us there are exceptions and some people born with so-called *Uner Tan* (or UTS) syndrome remind us of our ancestral animal background. People affected by this syndrome walk with a quadrupedal locomotion and are afflicted with "primitive" speech and severe intellectual disability. A genetic throwback like bear-walking is the reminders of our origins.

They could travel for kilometres like this, and the skin of their palms and feet was thicker. They had limited language skills and very little manual dexterity. They were born to an intermarriage family, where the parents were second cousins. It is likely this caused a faulty gene to be passed on by the parents to some of their children. The story of this family was featured in the 2006 BBC-documentary "*The Family That Walks on All Fours*"[187].

Thorough physical and medical investigations, including MRI scans, DNA and blood analyses by German and Turkish scientists, have shown that quadrupeds exhibit intellectual disability, and distorted (dysarthric) speech. Besides habitual quadrupedal locomotion, they tend to have a smaller or under-developed cerebellum (diffuse cerebellar hypoplasia), with simplified cortical gyri. One of them exhibited late-onset bipedalism, but could not stand up long nor walk too far.

DNA analyses by Professor Stefan Mundlos at the Max Planck Institute for Molecular Genetics in Berlin, Germany, found a patch of DNA where the family's mutation lies. The German team believed that in this family, the mutation switched off a gene for upright walking, allowing a much more ancient gene to resurface. A genome-wide linkage scan indicated their quadrupedal locomotion was a recessive trait linked to chromosome 17p. Based on these findings, Professor Mundlos claimed

[187] https://www.youtube.com/watch?v=Jwiz-yhLpT0&feature=youtu.be&t=13m14s "The Family That Walks On All Fours" This is a gripping film about a family of human "quadrupeds", who were touted by a Turkish scientist as evidence of "backwards evolution." Presented by Nicholas Humphrey, directed by Jemima Harrison. 2006. This is the full-length BBC version, preceding the edited NOVA version.

that humans can walk on all fours, and that this can be inherited as a genetic trait[188]. Furthermore[189], the researchers noted that "T*he genetic defect in this family disrupts the normal development of the cerebellum, the nucleus dentatus, and the corpus callosum. In addition, it is likely to affect yet unknown neuronal circuits that control bipedality. These subjects show signs of cerebellar ataxia and are mentally delayed. MRI analysis demonstrated hypoplasia of the cerebellum and the cerebellar vermis as well as a small nucleus dentatus and a thin corpus callosum but no other malformations.*"

The BBC documentary also highlighted unintentional neglect could also be a possibility considering the mother was producing babies in extraordinary rapid succession 7 children were born within 5 years - and 4 of those were quadrupeds, so that she must have been totally overwhelmed. They were poor villagers in a remote part of the country, and there was no proactive health care to help the mother, so that she simply didn't have enough time to hold their hands and walk them on their feet.

Mariel Young et al, (2022)[190] related humans' walking upright on their two legs to pelvic morphology. According to them, the shorter and wider reorientation of our pelvic blades and the largest and uppermost bone of the hip (the iliac bone) make it possible for humans to walk upright on two legs. This design also increases the size of the birth canal, which makes it possible for mothers to give birth to babies with large heads and big brains.

Excessive facial and/or body hair, sometimes called "werewolf syndrome" or hypertrichosis , can develop all over the body or it can cover the face and eyelids, while women grow thick patches of hair on their bodies. Some people are born with features that could remind us of our ancestral animal background.

Hypertrichosis is a rather rare condition, with fewer than 100 cases documented worldwide[191]. Men with this syndrome have hair hypertrichosis, which is also caused by a genetic mutation and does not have any other symptoms besides excessive hair growth[192].

A Chinese scientist, Xue Zhang, a professor of medical genetics at the Peking Union Medical College, found the underlying gene causing congenital hypertrichosis by comparing the DNA collected from

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[188] https://www.youtube.com/watch?v=Jwiz-yhLpT0&t=794s

[189] https://europepmc.org/backend/ptpmcrender.fcgi?accid=PMC2564522&blobtype=pdf

[190] Mariel Young et al, The developmental impacts of natural selection on human pelvic morphology, Science Advances (2022). DOI: 10.1126/sciadv.abq4884; Why do humans walk upright? The secret is in our pelvis. https://phys.org/news/2022-09-humans-upright-secret-pelvis.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

[191] https://dermnetnz.org/topics/hypertrichosis/

[192] https://www.ndtv.com/world-news/mexican-wolf-man-battles-isolation-of-rare-condition-1225620

a Chinese man and a Mexican family[193]. He found an extra chunk of genes on the X chromosome of the Mexican family and of the Chinese man. The responsible gene was a gene called SOX3, which is known to play a role in hair growth.

There were claims that hypertrichosis of a Spanish family was caused by a pharmaceutical mix up. Pharmacies in Granada, Cantabria and Valencia in Spain received mislabelled chemicals - a topical corticosteroid - which they then mixed into a formula to treat acid reflux in children. This was a hair loss prevention medicine (minoxidil) rather than omeprazole[194]. Twenty families signed up to a lawsuit to sue the pharmaceutical company responsible.

A young Thai girl aged 11 years named Supatra "Nat" Sasuphan was born with hypertrichosis[195]. She is known to have a Guinness World Record as the hairiest child. According to a judge's evaluation, Nat's upper lip, chin, chest, back, abdomen, arm, forearm, thigh, and lower leg were all covered with hair.

Inbreeding is not specific to humans, but is also seen among plants and other animals. Natural inbreeding in plants occurs all the time, in the form of self-pollination. Inbreeding can also be seen among some animals, especially isolated populations (such as those on an island). For example[196]: Banded mongoose females regularly mate with their fathers and brothers. Bed bugs, in contrast to most other insects, tolerate incest and can genetically withstand the effects of inbreeding quite well. Common fruit fly females prefer to mate with their own brothers over unrelated males.

Cheetahs' inbreeding goes back thousands of years, when they went through a population bottleneck that reduced their population dramatically. Thus the cheetahs that are alive today are all related to one another. A consequence of inbreeding for this species has been high juvenile mortality and low fertility[197].

With hundreds of thousands of creatures born in the world every day, it is inevitable that there will be some of them born with a rare abnormality[198]. There are furless (naked) animals such as the male chimpanzee, named Guru, living in Mysore Zoo in southern India[199], who suffers from

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[193] https://www.livescience.com/14430-werewolf-disorder-gene-discovered-excess-hair.html and https://www.thesun.co.uk/news/8383665/indian-boy-wolf-syndrome-bullies/

[194]https://www.dailymail.co.uk/news/article-7418535/Spanish-families-prepare-sue-pharmaceutical-company-kids-werewolf-syndrome.html

[195] https://www.livescience.com/13091-thai-girl-sets-world-hairiest-child-record.htm

[196] https://en.wikipedia.org/wiki/Inbreeding

[197] Wielebnowski, Nadja (1996). "Reassessing the relationship between juvenile mortality and genetic monomorphism in captive cheetahs." Zoo Biology. 15 (4): 353–369. doi:10.1002/(SICI)1098-2361(1996)15:4<353: AID-ZOO1>3.0.CO;2-A

[198] https://morbidology.com/8-extreme-animal-abnormalities/

[199]https://www.dailymail.co.uk/news/article-1322472/Guru-chimp-suffering-alopecia-looks-human-star-zoo-attraction.html ; Oct 13th 2020.

alopecia, a hair loss syndrome which affects the whole body. It is possible that homo sapiens have suffered from the same syndrome during their evolution and became a naked species like Guru.

There are animals born such as a giraffe with a crooked neck, or others with missing or extra body parts, like a dog with two legs, a cat with two faces, a four-legged duck, or a dog with two noses[200]. Even plants can have genetic abnormalities, such as those two eggplants shown in the picture below.

To sum up, the theory of biological evolution is a scientific alternative to religious beliefs. It claims that the universe and everything in it was created as a younger subset in the history of the evolution of the universe. Studies suggest that life on our planet did not happen overnight, or in six days, but over at least a couple of billion years.

Two abnormal eggplants are the result of human meddling (genetic engineering) gone awry.

In the next chapter, we will step back and start from the very beginning - from the formation of the universe to the eventual formation of the Earth. After all, Earth is a planet in this universe, and it is the universe that supplies the ingredients for the rise of all living organisms on Earth - the atoms of carbon, hydrogen, oxygen, nitrogen, and others that gathered and made the molecules, tissues, and organs of living beings. If there was no universe, there would be no Earth, and no living beings on Earth.

[200] Kirin Owens, 28th March 2018. https://morbidology.com/8-extreme-animal-abnormalities/

CHAPTER VI: HOW DID THE UNIVERSE, GALAXIES, STARS AND PLANETS FORM?

Why is the universe the way it is? Over the years, scientists have explored many ideas to explain the formation of our universe and determine its likely fate in the future. Two of the most well-known theories that attempt to explain the formation of the universe are the Steady State theory[201] and the Big Bang theory[202]. The well-known String[203] and Loop Quantum Gravity[204] theories are not fully fledged universe creation theories; hence they are not discussed here. In order to stay within the scope, in this book we have focused mainly on the Big Bang theory,[205] a universe-creation concept that is recognized by most scientists.

The other purpose of this chapter is to set the scene for the rise of living beings. Biological evolution on earth is believed to be a subsequent development in the history of the evolution of the universe, and it is this evolution that led to the creation of life on earth. This means that there would be no living beings, including us, if there was no universe for our galaxy called the Milky Way to exist. Even then, Earth needs some very special conditions to enable life to begin.

The Big Bang (standard model) theory and the Steady State theory are two theories trying to explain the beginning, mechanics and the evolution of the expanding universe. Let us start with the Steady State universe theory.

VI.1. THE STEADY-STATE UNIVERSE

The Steady State theory, also known as the continuous creation theory, is a cosmological theory. It Hoylewas developed independently in 1948 by Fred Hoyle and by Hermann Bondi & Thomas Gold, as an alternative to the Big Bang theory. However, the seeds of the Steady State idea were sown back in the 13th century by Siger of Brabant in his thesis "The Eternity of the World''. In his thesis, Siger argued that there was no first man, and that the physical universe did not have a beginning, and was therefore eternal. Siger's views were condemned by the pope in 1277.[206]

The Steady State model was supported by Albert Einstein even before Hoyle, Bondi, and Gold. We can know this from Einstein's 1931 manuscript where he added the cosmological constant *lambda*

[201] https://www.britannica.com/science/steady-state-theory

[202] https://en.wikipedia.org/wiki/Inflation_(cosmology)

[203] This theory is widely accepted as a potential solution to merging the science of the big—general relativity—with the science of the small—quantum mechanics.

[204] Loop quantum gravity – Wikipedia https://en.wikipedia.org/wiki/Loop_quantum_gravity

[205] https://en.wikipedia.org/wiki/Big_Bang

[206] https://en.wikipedia.org/wiki/Steady-state_model

to his famous field equation,[207] to ensure that the universe remains at a Steady State -neither shrinking or expanding.

According to this model, the universe is infinite in size and has always existed in the same state. It did not have a beginning nor an end. The universe in this model was flat, infinitely large, infinitely old (eternal), homogeneous and isotropic, with no apparent variation in its properties on a large-scale. It was continuously creating matter to stabilize the mass energy density of expanding space[208]. The Steady State model also claims that the distribution of matter and galaxies throughout the universe remains the same as the universe expands.

This ongoing creation of matter is called "continuous creation" and is the primary concept behind the Steady State model. However, this raises questions like how can density remain constant if the universe is expanding? The Steady State model answers this question by saying that the expansion of space is balanced out by a constant creation of matter, which causes the average density to remain constant. There was always a fresh supply of matter percolating throughout the universe to keep everything the same[209]. If you ask about the source of newly created matter, the answer lies in the vacuum of space. The theory posits that hydrogen atoms are formed from the energy present in this vacuum. Indeed, in quantum field theory, there are fluctuations in the vacuum that can lead to the temporary creation of particle-antiparticle pairs. However, these pairs are typically created as virtual particles and do not become stable, real particles that can be observed in the way classical particles are. They annihilate each other. The creation of real hydrogen atoms from vacuum fluctuations would require a trillions of degrees of heat (Big-Bang-like) to produce them as stable particles, and this is not something that happens spontaneously in empty space of the Steady State.

The Steady State theory has faced some other challenges over the years. Two pieces of evidence have been challenged in the Steady State model – cosmic microwave background radiation, and the redshift of light from distant galaxies. These have both suggested that there had been a significant event - an origin for the universe.

For example in 1948, Alpher and Herman calculations[210], and later the COBE satellite measurements, showed an extremely isotropic and homogeneous CMB temperature distribution of about 2.73 K. This led to the need for an inflationary phase[211] of strongly accelerated expansion.

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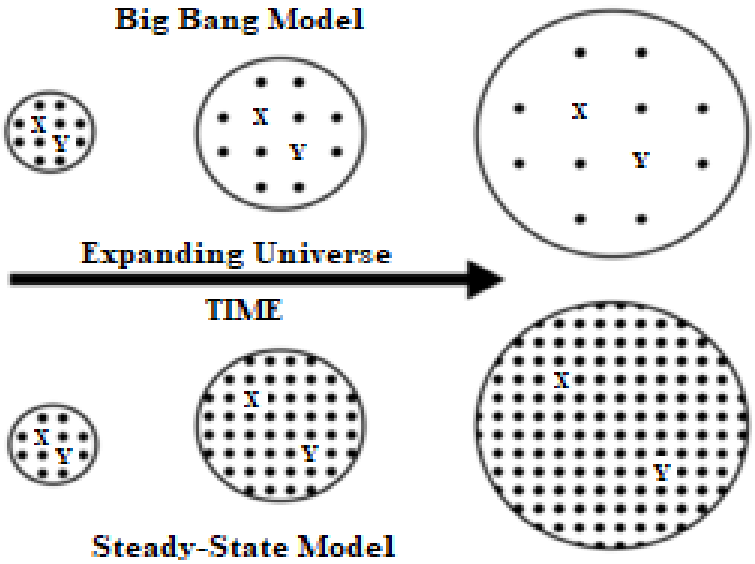
[207] ($G_{\mu\nu} + \Lambda g_{\mu\nu} = \kappa T_{\mu\nu}$) see for explanation https://en.wikipedia.org/wiki/Einstein_field_equations

[208] https://astro.uni-bonn.de/~pavel/Wikipedia/Lambda-CDM_model.html

[209] Michele Diodati (2020). An Eternal and Uncreated Universe or the Big Bang? https://medium.com/amazing-science/an-eternal-and-uncreated-universe-or-the-big-bang-12f5ccf7c4fd

[210] Alpher RA, Herman R. Evolution of the universe. Nature. 1948;162:774-775



In the Big Bang theory, matter is diluted over time as the universe expands. Whereas in the Steady State theory, matter is constantly created as the universe expands so that the density remains constant over time. Source: https://en.wikipedia.org/wiki/Steady-state_model.

The COBE satellite data also indicated that the CMB spectrum was a thermal black body spectrum, a remnant of the Big Bang. These findings disproved the claims of proponents[212] of the Steady State model[213] of the universe, who argued that the microwave background radiation was the result of scattered starlight from distant galaxies (op. cit.).

Please see the link given in the footnote[214] for pros and cons of the Steady State model, and for a comparison against the Big Bang theory.

These days the majority of astronomers and physicists believe in the Big Bang theory, and the Steady State model has been mostly abandoned.

VI.2. The Big Bang Theory

VI.2.A. Introduction

The Big Bang theory is the prevailing scientific explanation of the origin of the universe. In simple terms, the theory argues that the universe began as a singularity - a tiny point of infinitely dense matter that exploded approximately 13.8 billion years ago. The theory gets complicated as there

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[211] Guth AH. Inflationary universe—A possible solution to the horizon and flatness problems. Physical Review D. 1981; 23:347-356.

[212] Narlikar JV, Wickramasinghe NC. Microwave background in a Steady State universe. Nature. 1967;216:43-44

[213] Bondi H, Gold T. The steady-state theory of the expanding universe. Monthly Notices of the Royal Astronomical Society. 1948;108:252
Hoyle F. A new model for the expanding universe. Monthly Notices of the Royal Astronomical Society. 1948;108:372

[214] https://astro.ucla.edu/~wright/stdystat.htm Errors in the Steady State and Quasi-SS Models; https://www.differencebetween.com/difference-between-big-bang-theory-and-vs-steady-state-theory/ September 19, 2011

are old and new versions, and attempts to remove the singularity concept and introduce different ideas.

Alan Guth explained[215]: "*Despite the striking successes of the Big Bang theory, the theory in its original form is incomplete. Although it is called the "theory," it is not really the theory of a bang at all. It is only the theory of the aftermath of a bang. It elegantly describes how the early Universe expanded and cooled, and how matter clump to form galaxies and stars. But the theory says nothing about the underlying physics of the primordial explosion. It gives not even a clue about what banged, what caused it to bang, or what happened before it banged*". The inflationary universe theory, discussed below, is a description of the bang itself, and provides plausible answers to these questions and more.

According to the Big Bang theory, the universe expanded rapidly in the first few fractions of a second - a period called inflation. This expansion caused matter to cool and spread out, forming atoms, stars, and galaxies.

Evidence for the Big Bang theory includes cosmic microwave background radiation, which is the leftover heat from the early universe. This radiation is uniform across the entire sky, which supports the idea that the universe began as a single point and then expanded rapidly.

The discovery of the Hubble redshift in the 1920s also supports the Big Bang theory. Redshift occurs when light from distant galaxies appears to be shifted towards the red end of the spectrum, indicating that the galaxies are moving away from us. This suggests that the universe is expanding, and supports the idea that the universe began from a single point. Redshift is discussed in more detail later in this chapter.

Other strong evidence for the Big Bang model comes from the abundances of hydrogen, helium and lithium in the universe[216]. The Big Bang model delivers the extremely high temperatures needed to form the very first element, hydrogen, and the precursor for subsequent fusion reactions in the making of early atoms.

The Big Bang model predicts that these elements would have been produced during the first minutes after the Big Bang. The elemental abundances are temperature dependent, and only the high temperatures of a Big Bang like event would form these elements (op. cit.). Observations made in 2011 on the spectra of distant quasars (extremely luminous and energetic objects found at the

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[215] A. Guth, 1997. WAS COSMIC INFLATION THE 'BANG' OF THE BIG BANG? Published in "The Beamline" 27, 14 (1997). https://ned.ipac.caltech.edu/level5/Guth/Guth_contents.html

[216] Lawrence Krauss, 2012. A Universe from Nothing – Why There is Something Rather Than Nothing. Free Press eBook and Simon & Schuster, Inc. ISBN 978-1-4516-2445-8; ISBN 978- 1-4516-2447-2 (ebook)

centre of some galaxies) by the gas of primordial intergalactic clouds has confirmed the theoretical prediction, and established abundances (in terms of mass percentages) of about 76% hydrogen, 24% helium-4 and tiny amounts of deuterium, helium-3, and lithium-7 isotopes[217].

Other important supporting evidence based on astronomical observation[218] is that the oldest stars and primordial black holes in the universe are all only a little younger than the Big Bang event[219].

VI.2.B. THE THEORY

Georges Lemaître (1894-1966), a Belgian cosmologist and Catholic priest, is known as the father of the Big Bang theory[220]. He based his postulation on Einstein's *theory of relativity* and its basic assumptions, such as the isotropic and the homogeneous universe, namely a space that has the same look and behaviour in every direction, but not necessarily over time. He was the first person published in Flemish (a dialect of the Dutch language which is spoken in northern Belgium) in 1927. He proposed that the expansion of the observable universe began with the explosion of a single particle at a definite point in time[221].

Alexander Friedmann, a Russian physicist and mathematician, wrote the governing equations for the Big Bang theory[222]. Lemaître did not realise that similar equations had already been proposed by Friedmann in 1922. Although, Friedmann was more interested in the mathematics of a range of idealised solutions (including expanding and contracting universes), and did not pursue the possibility that one of them might describe the origin of the Big Bang universe[223].

Lemaître's paper published in 1927 provided a compelling solution to the equations of general relativity during the time when Edwin Hubble was using the world's largest telescope at Mt. Wilson in California. Hubble observed that the galaxies far from earth recede faster from earth than the galaxies closer to earth.

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[217] Michele Diodati (2020). An Eternal and Uncreated Universe or the Big Bang? https://medium.com/amazing-science/an-eternal-and-uncreated-universe-or-the-big-bang-12f5ccf7c4fd

[218] https://skyserver.sdss.org/dr1/en/proj/basic/universe/

[219] Gibney, E. (2015). Astronomers claim the first glimpse of primordial stars. Nature, 522, 401-402. https://doi.org/10.1038/nature.2015.17802. Or http://arxiv.org/abs/1504.01734 .
Nola Taylor Redd, 2011. Primordial star shouldn't exist - but there it is: https://www.nbcnews.com/id/wbna44346476
Michael Irving, 2021. Colossal primordial stars may have seeded supermassive black holes. https://newatlas.com/space/primordial-stars-may-have-seeded-supermassive-black-holes

[220] https://www.amnh.org/learn-teach/curriculum-collections/cosmic-horizons-book/georges-lemaitre-big-bang

[221] https://www.nationalgeographic.com/science/article/origins-of-the-universe

[222] https://www.differencebetween.com/difference-between-big-bang-theory-and-vs-steady-state-theory/

[223] Cosmic Horizons: Astronomy at the Cutting Edge, *edited by Steven Soter and Neil deGrasse Tyson, a publication of the New Press. © 2000 American Museum of Natural History* Georges Lemaître, Father of the Big Bang. Copyright Information All text, images, and software code on this website are copyright property of the American Museum of Natural History unless otherwise noted.

Lemaître's friend Eddington saw the importance of Lemaître's 1927 paper, and republished it in the English language in 1931, which made it available to the wider scientific community. This was an important moment for science, as it revolutionised the study of cosmology. Armed with Hubble's observations, Eddington was able to convince most astronomers that the universe was indeed expanding.

A year later, Lemaître proposed that if the universe is expanding, that it was smaller in the past, and extrapolation back in time should lead to an epoch when all the matter in the universe was packed together in an extremely dense state.

In 1930, Lemaître further proposed that our expanding universe actually began as an infinitesimal point which he called the *primeval atom*. He proposed that the primeval atom disintegrated in an explosion, giving rise to space and time and the expansion of the universe that continues to this day. This idea marked the birth of what we now know as Big Bang cosmology, although the term "Big Bang" is the brainchild of a devout proponent of the Steady State theory, astronomer Fred Hoyle. He described, rather mockingly, the prediction that the early universe was hot, dense, and rapidly expanding as a "big bang" during a BBC radio show in 1949.

Lemaître's ideas were developed further by other cosmologists, including George A. Gamow (1904-1968), to become the modern Big Bang theory. In 1946 Gamow, a Russian-American and devoted supporter of the Big Bang theory, claimed that the early universe was dominated by radiation rather than by matter[224]. Shortly before his death in 1966, Lemaître learned that Arno Penzias and Robert Wilson had discovered cosmic microwave background (CMB) radiation, the second most important observational piece of evidence in support of the Big Bang theory. Both Hubble's and CMB observations confirm the Big Bang theory. CMB radiation is discussed in more detail later in this chapter.

Since then, it was established that the entirety of space we can see from earth today began approximately 13.8 billion years ago by an explosive expansion of a small, solid mass of infinite density – singularity[225] although the dimensions of the singularity are unknown, and estimates range in size from a single atom to the size of a football, or even bigger[226]. All the mass and energy

[224] https://en.wikipedia.org/wiki/George_Gamow

[225] An uncompressed size of such a singularity will be a sphere with 10,000 km diameter. To such a sphere, all the positive mass matter of the present universe which weighs 1053 kg would fit. The number of positive mass particles needed to fill this sphere will be 0.5x1062 assuming these particles would have Planck length and Planck mass. Evidently, an awful lot of compression (106-fold) is needed to collapse this volume to a dot of 1 mm3 diameter. CHECK calculations https://www.gigacalculator.com/calculators/volume-of-sphere-calculator.php

[226] Inflation Stage: Plasma State https://www.abc.net.au/news/science/2019-09-19/before-the-big-bang-universe-cosmology-theoretical-physics-space/11452992

of the present universe was somehow concentrated into this small, solid mass. This explosive expansion event is referred to as the hot Big Bang.

The Big Bang theory is based mostly on mathematical equations. It explains how and when the universe came into existence, and provides a timeline of events in chronological order.

According to the theory, the Big Bang happened when quantum or vacuum fluctuations destabilised the singularity and caused it to explode. The expansion associated with the Big Bang created the present-day universe when the energy stored in the singularity rapidly discharged and began to expand, akin to a loaf of raisin bread rising. In this version of the theory, the universe was expanding like the after effect of an explosion[227].

Dongshan He and his team [228] showed, theoretically or mathematically, that a universe could be created from a vacuum fluctuation if the fluctuated (virtual) particles, comprising pairs of matter and antimatter, were separated from each other immediately (for example, by an extremely quick expansion) before they annihilated themselves. They would then form a balloon-like bubble, expanding exponentially and irreversibly. It is such an event that might create the present universe and real particles out of nothing, according to them.

According to their work, a small true vacuum bubble created by quantum fluctuations of a metastable false vacuum[229], would expand exponentially no matter whether the shape of the bubble was closed, flat or open.

It is theoretically possible for a universe to be created from a vacuum fluctuation. But, it is not clear if separating the virtual particles before they annihilate themselves is a viable mechanism for this process.

According to the standard model of particle physics, particles and antiparticles are always created in pairs that quickly annihilate each other. This releases energy in the form of photons or other particles. If this process were to occur in the early universe, it could lead to the creation of an entire universe, in which the matter and antimatter particles are somehow separated or prevented from annihilating each other.

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[227] https://www.pbs.org/wgbh/aso/databank/entries/dp29hu.html

[228] Dongshan He, Dongfeng Gao, and Qing-yu Cai, Spontaneous creation of the universe from nothing. http://arxiv.org/abs/1404.1207v1[gr-qc]

[229] A false vacuum exists at a local minimum of energy and is therefore metastable or not completely stable. This is in contrast to a true vacuum which exists at a global minimum and is stable.

In brief, while it is theoretically possible for a universe to be created from a vacuum fluctuation, the exact mechanism by which this would happen and how the matter and antimatter would be separated is still not fully understood.

Some cosmologists believe that newborn space first went through a period of exponential expansion known as "inflation," which lasted only for around 10^{-32} seconds. During the period of inflation, space suddenly ballooned from a small size to a several light-years size, after which the universe resumed its present (uniform and/or accelerating) expansion rate[230, 231].

During the early stages of the Big Bang, everything was in a state of hot plasma, where all fundamental particles were ionized and constantly collided with one another. This hot plasma emitted a uniform radiation called cosmic microwave background (CMB) radiation, which is still observable today and provides evidence of the hot plasma model.

As the universe cooled further, the plasma began to recombine into neutral atoms, and the universe became transparent to radiation. This event is known as recombination, and it occurred around 380,000 years after the Big Bang event. The Big Bang chronology is discussed in some detail in Chapter VI.3.

The Big Bang theory claims that the expansion of the Big Bang was not "into" anything. Rather, space confined to the balloon was just getting bigger. It was believed that there was no space or time before the Big Bang, so that this ballooning was the only space and the time we have. The process of inflation is thought to have lasted for only a fraction of a second, lasting around 10^{-36} seconds, when a type of energy field called an inflation field became dominant in the universe.

VI.2.C. COSMIC INFLATION (OR SIMPLY, INFLATION)

The theory of inflation sees the inflaton as a hypothetical field that spans all of spacetime, represented as some scalar (spin zero) particle. The theory of inflation proposes the universe expanded by a factor of about 10^{26} in 10^{-36} seconds around 13.8 billion years ago; then, the universe continued to expand, though not exponentially. During this early stage somehow dark energy was formed and sometime later, dark energy started the acceleration we see today[232]. Inflation is mostly accepted by cosmologists as a Pre-Big Bang event.

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[230] https://aether.lbl.gov/www/science/inflation-beginners.html

[231] Andrew May, July 16, 2021. *Ten wild theories about the universe*. https://www.livescience.com/strange-theories-about-the-universe.html

[232] David Appell, NOVEMBER 30, 2024. Cosmological model proposes dark matter production during pre-Big Bang inflation. Phys.org. https://phys.org/news/2024-11-cosmological-dark-production-pre-big.html

Alan Guth's Version

Cosmic inflation was proposed in 1979 physicists by Alan Guth and Andrei Linde as a solution to several vexing problems of the first version of the Big Bang cosmological model when they were investigating the problem of why no magnetic monopoles[233] are seen today. Their work found that according to general relativity, a positive energy false vacuum would generate an exponential expansion of space. Guth suggested that the universe expanded from an infinitesimal point in an incredibly short amount of time. This incredibly small point was perhaps as small as 10^{-24} cm, a hundred billion times smaller than a proton.

The inflation idea gained support because it explains some vexing questions in cosmology, such as the flatness problem, the homogeneity problem and the monopole problem, and it explains the origin of structure in the universe as quantum fluctuations that were enormously magnified[234, 235, 236].

There are many versions of inflationary theory but generically they assume that some small patch of the early Universe somehow came to be in a false vacuum state. Various possibilities have been discussed, including supercooling during a phase transition in the early Universe, or a purely random fluctuation of the fields. A chance fluctuation seems reasonable even if the probability is low, since the inflating region will enlarge by many orders of magnitude, while the non-inflating regions will remain microscopic. Once a patch of the early Universe is in the false vacuum state, the repulsive gravitational effect drives the patch into an inflationary period of exponential expansion. To produce a universe with the special features of the Big Bang discussed above, the expansion factor must be about 10^{25} to 10^{26}. Eventually the false vacuum decays, and the energy that had been locked in it is released. This energy produces a hot, uniform, soup of particles, which is exactly the assumed starting point of the traditional Big Bang theory. At this point the inflationary theory joins onto the older theory, maintaining all the successes for which the Big Bang theory is believed.

The process of inflation is thought to have lasted for only a fraction of a second, lasting around 10^{-32} or 10^{-36} seconds, when a type of energy field called an inflation field became dominant in the

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[233] Magnetic monopole is a particle with only one magnetic pole. The Big Bang theory predicts that the early universe should produce a large number of heavy, stable magnetic monopoles. However, no magnetic monopoles have ever been observed, so they are either much rarer than predicted, or they don't exist at all.

[234] The Big Bang theory predicts that magnetic monopoles should have been created in large numbers in the early universe. This is because the universe went through a violent phase transition when the four fundamental forces split, which could have left defects in the fabric of spacetime. These defects could have taken on the properties of a magnetic monopole.

[235] J. Alberto Vazquez, Luis E. Padilla, Tonatiuh Matos, 22 Dec 2021. Inflationary Cosmology: From Theory to Observations >astro-ph>arXiv:1810.09934

[236] https://ned.ipac.caltech.edu/level5/Guth/Guth3.html

universe. This field caused the universe to expand exponentially, smoothing out any irregularities and creating a homogeneous and isotropic universe. This rapid expansion diluted any matter and energy that was already present, and released the energy needed to make the universe flat. Inflation also magnified density differences on the smallest scales, which eventually helped form the universe's large-scale structures[237].

Alan Guth's version presented above is now known as the old inflation theory, or original inflationary theory. Its basis is that the universe was formed through tunnelling out of a false vacuum state.

Although inflation is mostly accepted by cosmologists, the driver of inflation is still unknown with certainty. One explanation is the repulsive gravitational field of a false vacuum drives cosmic inflation. A false vacuum is a state of matter with a high energy density that cannot be quickly lowered. The negative pressure of the false vacuum is so large that it overcomes the positive energy density, creating a repulsive gravitational field[238].

Another explanation[239-240] suggests that the inflation could be related to the Higgs bosons and the Higgs field that drives the cosmic inflation, producing fluctuations necessary for structure formation. The Higgs field can decay during inflation in a metastable vacuum. This idea found some support when the Higgs boson was discovered at the Large Hadron Collider.

The Higgs mechanism offers a new perspective on the cosmic inflation and on the relationship between elementary particles and dark energy which drives the accelerating expansion of the universe[241]. The Higgs field is a field of energy that permeates spacetime, but it is not equivalent to spacetime. Additionally, the Higgs field is not considered a force, as it doesn't transfer energy or accelerate particles. However, it does interact with all particles, except for massless ones, to give them mass.

One of the strengths of the inflationary theory is that it explains the observed cosmic microwave background radiation, which is thought to be a relic of the early universe. The theory predicts that the cosmic microwave background radiation should be uniform in all directions, with small fluctuations due to quantum mechanical fluctuations in the inflation field.

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[237] https://science.nasa.gov/universe/overview/

[238] https://ned.ipac.caltech.edu/level5/Guth/Guth3.html

[239] Katherine Freese et al, Dark Matter Production during Warm Inflation via Freeze-In, Physical Review Letters (2024). DOI: 10.1103/PhysRevLett.133.211001. Journal information: Physical Review Letters

[240] Manda Malekpour, Kourosh Nozari, arXiv [2404.12099] Higgs Inflation in Unimodular Gravity - arXiv [Submitted on 18 Apr 2024 (v1), last revised 13 Jun 2024 (this version, v3)]

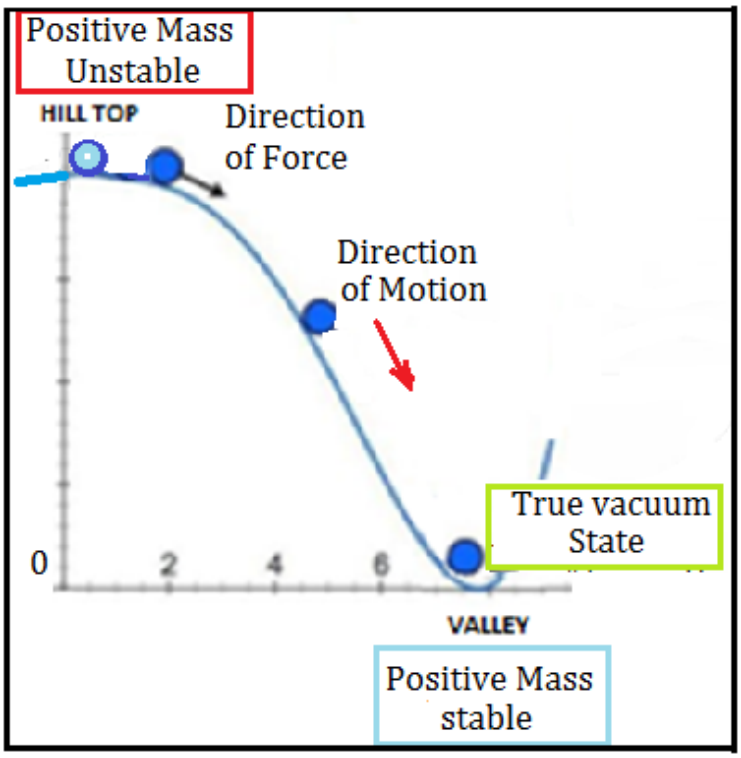
[241] Manda Malekpour, Kourosh Nozari, arXiv [2404.12099] Higgs Inflation in Unimodular Gravity - arXiv [Submitted on 18 Apr 2024 (v1), last revised 13 Jun 2024 (this version, v3)]

However, despite its successes, this version of the inflationary theory had some shortcomings. For instance, the theory did not provide a mechanism for the inflation field to settle into its low energy state, known as the electroweak symmetry breaking scale, after inflation. This led to the development of a new inflationary model that attempted to address these issues.

An improved version of the original inflationary theory is the new inflationary theory, also referred to as the slow-roll inflation theory. In this version, inflation is driven by a scalar field, which means it has a value at each point in space, and as this field rolls down its potential energy curve, it leads to a phase of accelerated expansion. In standard inflationary models, the inflation eventually decays, leading to reheating and subsequently to the Big Bang.

This scalar field was in a high-energy state during the early universe, and when it decayed to a lower-energy state, it caused the universe to expand rapidly. However, if the field were to suddenly decay, it would result in the universe collapsing back on itself.

To prevent this from happening, the inflation field needed to decay slowly rather than suddenly. During this slow decay, the inflation field released energy particles that drove the rapid expansion of the universe[242].



Depiction of the beginning and the end of (cosmic) inflation theory according to Siegel.

[242] https://en.wikipedia.org/wiki/Inflation_(cosmology)

Ethan Siegel[243] explained the new version of the inflation theory with a rolling ball illustration (see figure below). This slow decay is where the term slow-roll comes from.

Ethan Siegel (op.cit.) explained: "*The Inflation period, defines a very early period of time where all of the energy that would go into the matter and radiation present today was instead bound up in the fabric of space itself. That period, known as cosmic inflation, came to an end and gave rise to the hot Big Bang, but the inflation itself never created an arbitrarily hot, dense state, nor did it create a singularity. The Universe was filled with energy inherent to space itself, and that energy caused space to expand at a rapid, relentless, and exponential rate. At some point, inflation ends, and all (or almost all) of that energy gets converted into matter and energy, giving rise to the hot Big Bang. The end of inflation, and what's known as the reheating of our Universe, marks the start of the hot Big Bang*".

Siegel pictured inflation as a ball rolling very slowly on top of a flat hill in the figure above. As long as the ball remains on the flat hilltop, inflation continues. When the ball reaches the end of the flat part of the hilltop and tips over the hill, it rolls down into the valley below. This converts the energy from the inflationary field itself into matter and energy. This conversion signifies the end of inflation through a process known as reheating, and it gives rise to the hot Big Bang we're all familiar with.

When the ball tips over the hill and starts rolling down the hill, the large potential energy of the inflation field decays into particles and fills the universe with the fundamental particles. These include electromagnetic radiation, starting the radiation dominated phase of the universe. Because the nature of the inflation is unknown, this process is still poorly understood. Although, it is believed to take place through a parametric resonance (op.cit.) or a parametric oscillator, a state of vibration in which energy flows into the system from a resonating external source, increasing the amplitude of the system's response[244].

Slow-roll inflation is an essential theory to explain the origins of the universe. It provides a possible explanation for the rapid expansion of the early universe, which eventually leads to the formation of the galaxies and stars we see today.

This version of the inflationary theory also claims that the inflationary phase was not a smooth and uniform process, as was originally assumed. Instead, the inflationary phase was a chaotic process, with the inflation field (the hypothetical field that drove the inflationary phase) undergoing vacuum

[243] https://www.forbes.com/sites/startswithabang/2018/07/17/what-is-and-isnt-scientific-about-the-multiverse/
[244] https://www.sciencedirect.com/topics/engineering/parametric-resonance

or quantum fluctuations[245] that led to the formation of density fluctuations in the early universe. These density fluctuations eventually evolved into the large-scale structure of the universe we observe today, such as galaxies and galaxy clusters.

The chaotic nature of the inflationary phase also explains why the universe appears to be homogeneous and isotropic on large-scales, despite the quantum fluctuations that occurred during the inflationary phase.

The new inflationary theory also addresses some of the other shortcomings of the old inflationary theory. For example, it explains why the universe appears to be flat and why the density of matter in the universe is so precisely tuned. These are known as the flatness and horizon problems. The theory suggests that these fluctuations were amplified by inflationary expansion, causing a flatness and smoothness of the universe on large-scales.

Overall, scientists consider the new inflationary theory provides a comprehensive and elegant explanation for the formation of the large-scale structure of the universe, and offers insights into the fundamental nature of the universe.

There were other versions of the inflationary theory too, among them the hybrid inflation theory, which is an extension of the new inflation theory. It introduces additional scalar fields, so that while one of the scalar fields is responsible for normal slow-roll inflation, another triggers the end of inflation: when inflation has continued for a sufficiently long period of time, it becomes favourable to the second field to decay into a much lower energy state[246]. Eternal Inflation extends the cosmic inflation theory and proposes that inflation is not a special event that occurred only once - to create our universe - but rather a continuous process that gives rise to a multiverse, many universes. According to eternal inflation, quantum fluctuations of the inflaton field can cause different regions of spacetime to experience different rates of inflation. Some regions may stop inflating while others continue, creating "bubbles" of space that are no longer experiencing inflationary expansion. These bubbles eventually stop inflating and can give rise to what we observe as our universe.

Since its first introduction by Alan Guth, the inflationary theory has become widely accepted. Nevertheless, the theory was not immune to criticisms based largely on claims pointing out that the predictions are not testable and that it lacks serious empirical support (op. cit.).

[245] Vacuum fluctuations refer to the random and brief appearance and disappearance of particles and antiparticles in the vacuum – the empty space of the universe. These particles and antiparticles can be thought of as virtual particles, that exist for a very short period of time before annihilating each other, leaving no net change to the vacuum energy.

[246] https://en.wikipedia.org/wiki/Inflation_(cosmology)

Cosmic inflation is explained in detail in Wikipedia (op. cit.) where extensive references are also provided.

VI.2.D. EXPANSION

What makes the universe expand, and what it is expanding into? Based on astronomical observations, the universe is expanding because the distance between galaxies and clusters of galaxies is increasing over time. This expansion is driven by a theoretical concept known as dark energy. In this section, we discuss what is currently understood about dark energy and the expansion of our universe.

Dark energy is a form of energy that is distributed throughout the universe. It exerts a gravitational force that causes the fabric of space to stretch out over time.

The present belief says the universe is not expanding into anything. Rather, the expansion is a property of space itself. So, the expansion phenomenon is not due to galaxies pushing away one another. Rather, it is an expansion of spacetime itself. As such, it is the space between galaxies that is stretching, which results in the phenomenon we observe. The objects (galaxies) themselves do not get bigger or move relative to each other, like raisin bread when the baked dough expands but the raisins remain the same size.

Dark energy is an unknown form of energy that is thought to permeate the fabric of spacetime. It has a negative pressure that causes the universe to expand. The observations of distant supernovae, cosmic microwave background radiation, and the large-scale structure of the universe all support the idea that dark energy exists and is driving the expansion of the universe. The dark energy is discussed in some detail later in Chapter VI.4.C.

Expansion was first observed by the astronomer Edwin Hubble in the 1920s. Since then, scientists have confirmed that the universe has been expanding ever since the Big Bang. The exact nature of dark energy is still not fully understood, but it is believed to make up 69 to 70% of the total energy density of the universe. The Hubble space telescope is one of the most influential scientific instruments that paved our understanding of the universe's expansion.

The universe cools as it expands. This leads to a decrease in the overall energy density. It is this change in energy density which led to the formation of matter, including galaxies, stars, planets, and the cosmological world we see today.

When we say that something is expanding, it must be expanding into a medium (at least on earth). If that is the case, then what is the universe expanding into? Scientists have attempted to answer

this question in a general way - the universe is not expanding into anything, because there was neither space nor time before the Big Bang. In other words, the universe came out of nothing[247]. In their view, nothing was a void - a completely empty vacuum. However, we intuitively know that nothing comes out of nothing, so surely that nothing must be something!

That something on earth is a medium - an air or gas or liquid to carry the expansion. For example, to expand a balloon[248], we need someone to blow or pump air into it. We know that an explosion creates shock waves which manifest themselves by forcefully pushing the surrounding air. When we drop a stone into a water pond, the little circular waves are carried away by the water in the pond.

The transmission medium for sound is usually air. But what was the medium that transmitted the explosion of the Big Bang and made the empty vacuum space expand? The answer to this question is usually negative (repulsive) pressure generated by dark energy. Dark energy is also sometimes called antigravity, because it behaves like the opposite of gravity[249].

Nuclear tests in space can give us some clues about what would happen if a nuclear bomb exploded in outer space. On earth, a blast usually creates heat, light and a loud shockwave. Would the effect of an explosion be the same in empty space?

A shockwave is the disturbance of material that is created when a wave of a blast moves through a medium at greater than the local speed of sound. As there is no air in space to carry the effect of the blast, how can shockwaves travel through outer space, in a vacuum?

Nuclear tests in outer space were carried out by the Soviets[250] and the U.S[251] military in 1961-1962, and have provided some answers to this question. In total, 10 nuclear tests were carried out by these two countries (5 tests by each country). The U.S tests were done some 400 kilometres above Johnston Island in the Pacific Ocean, several hundred kilometres southwest of Hawaii. These experiments showed that in the vacuum of space, the lack of air means the principal destructive effects would come not from the blast, but from the high energy particles and radiation(photons

[247] He, Dongfeng Gao, and Qing-Yu Cai, (2014). Spontaneous creation of the universe from nothing. http://arxiv.org/abs/1404.1207v1[gr-qc]

[248] Baking resin bread is a better example as the size of the resins (*galaxies*) does not change when the bread expands.

[249] https://astronomy.swin.edu.au/cosmos/d/dark-energy

[250] https://en.wikipedia.org/wiki/Soviet_Project_K_nuclear_tests

[251]https://web.archive.org/web/20101105204805/http:/www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA955411&Location=U2&doc=GetTRDoc.pdf

with electrons created by the blasting material) pouring out of the explosion, which would dump their energy as heat on striking every object on its path[252].

Shock waves are quite common phenomena in outer space. An example close to our home on Earth is solar flares, which create solar winds. When solar winds hit the magnetosphere, a magnetic shield around Earth, bow shocks form[253]. If you could imagine that a solar flare was happening inside of a balloon (ignoring the burning of the rubber itself), the balloon would be expanding in every direction.

We also know that supernova explosions create powerful shocks. The shocks happen both within the star collapsing to form the explosion, and moving through the interstellar medium itself. Interstellar shocks can also occur simply by the collision or collapse of gas clouds.

Black holes, high-density objects such as pulsars, merging galaxies and even just the motion of galaxies themselves are also all known to form shockwaves of various forms [(op. cit.)]. Nuclear tests in outer space have shown that[254] a very high frequency radiation is emitted from the explosion. The thermal radiation disappears quickly in the absence of air, but it does not suffer any physical reduction or degradation. The only degradation in intensity is related to the distance from the blast site. This means that the objects on the path of the radiation will receive higher doses of radiation than an object further away.

It is expected that even sound waves would travel at the very early stage of the Big Bang. The gaseous particles of dense plasma (condensate) and radiation (microwaves) should provide the required medium for sound to travel. But in an inflating or expanding universe, the density of the plasma gas thins so low that the radiation cannot transmit its pressure to the gas, so that the sound can no longer propagate[255].

There are also theoretical findings indicating that the vacuum of outer space is in fact not empty, and rather it is filled with an unknown energy[256]. Professor Derek Leinweber at the University of Adelaide, Australia showed that the energy filling the vacuum of outer space constantly fluctuates. This creates pairs of particles with mass, such as electrons and positrons that instantly annihilate each other[257] . These fluctuations occur on a tiny scale, measuring the size roughly equivalent to

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[252] https://www.sciencefocus.com/space/what-would-happen-if-a-nuclear-bomb-was-detonated-in-space/

[253] https://www.sciencefocus.com/space/can-you-have-a-shock-wave-in-space/

[254] 17. NUCLEAR WEAPON EFFECTS IN SPACE. https://history.nasa.gov/conghand/nuclear.htm U. S. Department of Defence, published by the Atomic Energy Commission, June 1957.

[255] Dr. Randy Jokipii (January 2006) Sound from the Big Bang. https://cosmicopia.gsfc.nasa.gov/qa_sp_en.html

[256] https://www.youtube.com/watch?v=J3xLuZNKhlY

[257] http://www.physics.adelaide.edu.au/theory/staff/leinweber/

two protons. Additionally, the simulation operates at an astonishingly rapid frame rate of one million billion billion frames per second.

In very simple terms, gluons are the *glue* that binds quarks together within the nucleus of an atom. Empty space is therefore a field of fluctuating quarks and gluons (see Chapter VI.8). Apparently, as Prof. Leinweber put it, on average, it is possible to annihilate a quark from a supposedly empty but fast-bubbling soup. Further details are available in the publication in footnote below[258].

It is now clear that unlike in classical mechanics, quantum systems constantly fluctuate in their lowest energy state. This is described by the Heisenberg uncertainty principle. Even at absolute zero, atoms and molecules are slightly vibrational.

According to quantum field theory, the universe is not made of isolated particles but rather continuously fluctuating matter fields, whose quanta are leptons and quarks, and force carriers such as gluons, bosons and photons. All these fields have zero-point energy (see next section).

Fluctuating zero-point fields have led to a revival of the aether concept in modern physics[259]. The empty space of our universe is not only empty between stars or galaxies. Similarly, atoms also seem to be made of mostly e*mpty* space but filled with some unknown energy. For example, a hydrogen atom is known to be about 99.9999999999996% *empty* space[260]. Every mass in the universe is made from trillions and trillions of atoms, which are nearly all *empty* space. If we were to remove all the empty space contained in every atom present in the entire universe and compress the atoms, then the overall volume of the compressed particles would possibly be a small singularity.

We do not know whether the empty space in an atom is really empty, or like the empty space of the universe, whether it is filled with some unknown matter or energy. It is possible that the binding energy of gluons that hold quarks together could in fact be the weight of the *empty* space, since energy and mass are equivalent.

It has become clear that what we call a completely empty vacuum is not truly empty at the quantum level. The empty vacuum (or empty space) is an arena full of action, fluctuations, and virtual particles, pairs of matter and antimatter such as electrons and positrons, whizzing out, quickly annihilating each other, converting to gamma energy, and disappearing. When we say that gamma energy (radiation) is disappearing, what we in fact mean is that it returns to the empty vacuum, but

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[258] ``Gluon flux-tube distribution and linear confinement in baryons'' by F. Bissey, F. G. Cao, A. R. Kitson, A. I. Signal, D. B. Leinweber, B. G. Lasscock and A. G. Williams. Phys. Rev. D 76, 114512 (2007) 16 pp. or [arXiv:hep-lat/0606016]. http://www.physics.adelaide.edu.au/theory/staff/leinweber/VisualQCD/Nobel/

[259] https://en.wikipedia.org/wiki/Zero-point_energy

[260] https://education.jlab.org/qa/how-much-of-an-atom-is-empty-space.html

only to reappear as another pair of matter and antimatter. It is as if energy and mass are playing a game of hide and seek.

VI.2.E. Dark energy Fills The Universe And Makes It Expand

Dark energy is a hypothetical form of energy that is believed to exist at this moment of time. It is called "dark" because it is invisible to even our most sophisticated instruments designed to detect it. Scientists believe in the existence of dark energy because it seems to explain the expansion of the universe and the movement of galaxies apart from one another.

Dark energy[261] is thought to be a form of energy that is evenly distributed throughout space, creating a negative pressure which causes space to expand at an accelerating rate, hence acts like antigravity – the force that pushes the galaxies away from each other. So, dark energy is the opposite of gravity - the force that pulls the matter.

It is believed that, although weak against gravitating matter, dark energy is still strong enough to pull apart the space between galaxies. As far as we know, galaxies themselves do not expand due to the strong gravitational pull between stars. According to NASA[262], based on the movement of galaxies away from each other, the universe expands at a rate of 73 ± 1 kilometre per second per megaparsec[263].

This means that the size of the universe will be doubled in about 10 billion years[264]. That also means our universe will be much colder. Ten billion Earth years is actually near to nothing in terms of galactic years, as it would be only approximately 50 orbits of our Sun around the Milky Way.

Dark energy is a hypothetical form of antigravitating energy that fills the entire universe. Dark energy's existence has been hypothesised to account for the observational properties of distant 1A type supernovae, which show the universe going through an accelerated period of expansion[265].

Type IA supernovae are a type of exploding star that can be used as standard candles – objects whose intrinsic brightness is known, allowing their distance to be determined. These observations

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[261] The word dark in dark energy refers to the fact that it is unknown, not to a dark colour.

[262] https://www.nasa.gov/feature/goddard/2022/hubble-reaches-new-milestone-in-mystery-of-universes-expansion-rate

[263] A megaparsec (Mpc) is a measurement of distance equal to one million parsecs or 3.26 million light years.

[264] This means that a galaxy 1 megaparsec will be moving away from us at a speed of about 73 km/sec and similarly another galaxy 10 megaparsecs away will be receding at about 730 km/sec speed.

[265] https://www.astronomy.swin.edu.au/cosmos/D/Dark+Energy

were surprising and unexpected, since they came at a time when people generally believed that the universe was slowing down due to the gravitational attraction of galaxies[266].

In 1998, when physicists discovered that the expansion of the universe is accelerating, it became obvious that normal matter could not make this happen. A theoretical new energy, called dark energy, was introduced[267]. It has been ruled out that dark energy is made out of massless particles like photons.

According to the current model of the universe, there are three primary components - ordinary matter, dark matter, and dark energy. Ordinary matter makes up approximately 5% of the universe's mass-energy density. It is the visible matter which forms stars, planets, and asteroids. Dark matter is an invisible form of matter which weakly interacts with ordinary matter, but makes up approximately 25% of the universe's mass-energy density. The remaining 70% of the universe's mass-energy density is dark energy. It exists theoretically throughout space. An expanding universe concept is permissible as it doesn't have time symmetry, so it does not violate the law of conservation of energy.

The concept of dark energy is based on Einstein's Theory of General Relativity, which describes how gravity affects the universe. In this theory, gravity is caused by the curvature of space and time around massive objects.

There are a few theories which attempt to explain what dark energy could be, such as a cosmological constant or a type of scalar field. However, there is currently no experimental evidence to verify any of these theories. At present, dark matter and dark energy cannot be readily explained by any known theories of physics. This is leading scientists to consider whether there is another unknown force, or whether an exotic particle exists.

One of those ideas that claim dark energy is made of exotic matter with negative mass comes from Bondi (1957)[268] and Choi (2012)[269]. According to them, a matter with repulsive gravitational properties would cause space to expand. Any particle with negative mass would push each other apart.

At present, it is generally believed that dark energy is not a particle, because it doesn't appear to interact, clump or cluster the way that other particles do. However, we think these particles are

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[266] Brian A. Robson (Ed), 2019. Redefining Standard Model Cosmology DOI: 0.5772/intechopen.85605; https://www.intechopen.com/chapters/66783

[267] http://arvinash.com/how-the-universe-will-end-and-how-we-can-escape/

[268] H. Bondi (1957). Negative Mass in General Relativity. Rev. Mod. Phys. 29 No. 3 July 1957.

[269] Heoyoung Choi (2012). Is the Low Energy State Stable? Negative Mass And Negative Energy. [http://www.youtube.com/watch?v=MZtS7cBMIc4].

extremely small (Planck size), which would be well below the detection limits of our most advanced instruments. We presented our views on dark matter and dark energy in Chapter XI.

In physical cosmology it is uniform energy density with a sufficiently negative pressure which causes expansion[270]. Dark energy permeates space uniformly everywhere - it has neither a preferred reference frame nor is it required as a medium for anything to travel through.

The fact is that we simply do not know much about dark energy. Currently, we do not know whether the universe is expanding with the same dark energy density like in the Big Bang model, or if it is expanding with the creation of more and more dark energy like in the Steady State model.

Two other pillars that support the Big Bang theory are CMB radiation and the redshift phenomenon[271] that are discussed in the following two sections.

VI.2.F. CMB (Cosmic Microwave Background) Radiation

Cosmic microwave background (CMB) radiation is suggested as a crucial piece of evidence that supports the Big Bang theory. Its uniformity across the sky and its precise level of thermal consistency provide strong evidence that the universe was once in a very hot, dense state.

One of the key predictions of cosmic inflation is the existence of CMB radiation, which is thought to be a remnant of the Big Bang. Inflation would have caused the universe to expand so rapidly that any fluctuations in temperature or density would have been stretched out to cosmic scales, leaving a nearly uniform background radiation.

CMB radiation was first discovered in 1964 by two radio astronomers named Arno Penzias and Robert Wilson. They were studying the faint radio waves emitted by our galaxy, the Milky Way. They discovered a faint, low-level thermal radiation that was present at all time, and in all directions in the sky. This radiation was later identified as CMB radiation and has been the subject of extensive study ever since.

Further research has shown that this radiation was not caused by any known sources in the universe, but rather that it represented the afterglow of the Big Bang. The Big Bang theory predicts that the universe was filled with extremely hot, dense matter in the early stages of its evolution. As

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[270] Ethan Siegel (July 26, 2012): https://scienceblogs.com/startswithabang/2012/07/26/empty-space-has-more-energy-than-everything-in-the-universe-combined

[271] In physics, a redshift is an increase in the wavelength, and corresponding decrease in the frequency and photon energy, of electromagnetic radiation. The Doppler red-shift of light observed from distant stars and galaxies gives evidence that the universe is expanding (moving away from a central point) as the spectral colour becomes red. This supports the Big Bang theory, because after a "bang" occurs all the matter moves away from the point of origin. (See VI.2H) https://louisville.edu/planetarium/research/implementation/visualization-scripts/high-school/hs-module-1

the universe expanded and cooled, this matter eventually became transparent, and the radiation it emitted at the time became stretched out and redshifted, becoming the cosmic background radiation we see today.

The CMB Radiation is a field of invisible electromagnetic radiation (light) that fills the entire universe. When the universe was formed it was much smaller and hotter, filled with glowing hot plasma. We still see the end of this extremely hot phase as a sea of radiation filling the entirety of outer space. The most detailed map of the Cosmic Microwave Background (CMB) radiation was created by the WMAP and ESA's Planck satellites. They found that the temperature variations are unusually uniform in every direction of the sky, and correspond on average to 2.725 K, and these variations are in the order of microkelvins. Comparing the statistics of the measured data with theoretical calculations shows very good agreement.

The expansion of the universe over billions of years has cooled the radiation down to about minus 270° Celsius (or about 3 degrees Kelvin). The CMB radiation is detectable by radio telescopes like the Atacama Cosmology Telescope, satellites like COBE in 1989 and WMAP (Wilkinson Microwave Anisotropy Probe) in 2001 and the Planck Probe in 2009.

The measurements made by the radio telescopes and satellites have made it possible to record tiny variations in CMB with the highest level of detail, without the blurring caused by the filter of the Earth's atmosphere.

These measurements have shown that CMB radiation perfectly matches the characteristics predicted by the Big Bang hypothesis. Namely, that CMB radiation comes from all directions in the sky, it has an almost identical temperature everywhere (equal to 2.725 K ± 470 microKelvins), and has a frequency spectrum that is similar to that of blackbody radiation[272].

VI.2.G. REDSHIFT

Redshift[273] is another phenomenon that supports the Big Bang. In astronomy, redshift means when the wavelength of light appears to lengthen to become long waves, which moves it towards the red end of the electromagnetic spectrum. It is an important concept in the study of the universe,

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[272] Wikipedia, https://en.wikipedia.org/wiki/Black-body_radiation, defines BBR: "Black-body radiation is the thermal electromagnetic radiation within, or surrounding, a body in thermodynamic equilibrium with its environment, emitted by an idealized opaque, black non-reflective body. It has a specific, continuous spectrum of wavelengths, inversely related to intensity, that depend only on the body's temperature, which is assumed, for the sake of calculations and theory, to be uniform and constant."

[273] A redshift is an increase in the wavelength, and corresponding decrease in the frequency and photon energy, of electromagnetic radiation. The Doppler redshift of light observed from distant stars and galaxies gives evidence that the universe is expanding (moving away from a central point) as the spectral colour becomes red. This supports the Big Bang theory, because after a "bang" occurs all the matter moves away from the point of origin. https://louisville.edu/planetarium/research/implementation/visualization-scripts/high-school/hs-module-1

providing evidence for the expansion of the universe and helping astronomers to determine the distance and speed of objects in space.

Redshift is caused by the Doppler Effect, which is the change in frequency of a wave when the source and observer are in relative motion. When an object in space moves away from us, its light waves stretch, causing a redshift. Conversely, if an object moves toward us, the light waves compress, shifting towards the blue end of the spectrum - known as blueshift. There are many observations of redshift and a few blue-shifts from our universe.

The redshift phenomenon has been observed in the light of distant galaxies. It provides evidence for the expansion of the universe because as the universe expands, the distance between galaxies increases, causing their light to be stretched and shifted towards the red end of the spectrum.

Measurements are done by inferring an absolute brightness of a star, then measuring its apparent brightness with telescopes. Ultimately the distance to a host galaxy can then be determined. Measuring the redshift of a galaxy also allows us to determine velocity. Combining the two then allows us to measure the expansion rate of the universe[274].

The amount of redshift observed in the light of a galaxy can be used to determine its distance from Earth. This is done by comparing the observed redshift to the expected redshift based on the known properties of the galaxy. By doing this, astronomers can calculate the recessional velocity of the galaxy - the speed at which it is moving away from Earth.

Astronomical observations[275] clearly show that light shifts towards red and that therefore the universe is expanding. Edwin Hubble's (1889-1953) astronomical observations showed us that galaxies are moving away from each other. Hubble and others showed that redshift in the electromagnetic spectrum of galaxies was directly proportional to the distance of the galaxy from Earth. That meant that galaxies further away from Earth were moving away faster. Therefore, the universe must be expanding and the Big Bang was the start of both space and time[276].

The rate of expansion of the universe was determined for the first time by Vesto M. Slipher (1875-1969), an astronomer at the Lowell Observatory in Flagstaff, Arizona, USA. Slipher showed that the Sombrero Nebula is moving away from the Earth at an incredibly rapid rate of 4 million kilometres

[274] Lawrence Krauss, 2012. A Universe from Nothing – Why There is Something Rather Than Nothing. Free Press eBook and Simon & Schuster, Inc. ISBN 978-1-4516-2445-8; ISBN 978- 1-4516-2447-2 (ebook)

[275] Vesto Slipher, (1917): Proc. Amer. Phil. Soc., 56, 403

[276] https://theconversation.com/curious-kids-what-existed-before-the-big-bang-did-something-have-to-be-there-to-go-boom-103742

per hour[277]. However, in some cases stars or galaxies such as the Andromeda galaxy are actually approaching us. Therefore, their approach shifts the light to blue which is known as blueshift.

VI.2.G. BGV (Borde-Guth-Vilenkin) Theorem

The Borde-Guth-Vilenkin theorem claims that "*No cause is needed for the universe to pop out of nothing?*"[278]. In quantum physics, events do not necessarily have to have a cause, because there is, whether small or large, a probability for the universe to pop out of nothing. Quantum mechanics shows that particles are waves of probabilities – and these waves have a non-zero probability of showing up spontaneously outside a barrier through a process called quantum tunnelling. It turns out that there is a probability, not very large, but a non-zero probability that a zero-size universe can tunnel through an energy barrier and become a finite size universe[279]. Quantum tunnelling is a real phenomenon that can be measured and is known to exist. For example, this is how an electron or even an atom behind a barrier has a small probability of showing up on the other side of the barrier (op. cit.). In essence the theorem says that no cause is needed for this to happen - the process is completely random and just happens.

The BGV theorem does not assume any specific mass content of the universe, and it does not require gravity to be described by Einstein's field equations[280]. The BGV theorem is for an expanding homogeneous isotropic flat spacetime universe, and it is consistent with the current ΛCDM (lambda cold dark matter) model of cosmology. The BGV theorem can be applied to any spacetime and does not require homogeneity or isotropy (op. cit.).

VI.3. Big Bang Chronology Of Our Universe

The Big Bang provides a timeline for its evolution which is well documented by scientists, particle physicists, and astronomers. The chronology of events following the onset of the Big Bang is presented largely based on information gathered from https://en.wikipedia.org/wiki/Chronology_of_the_universe. However, let us highlight that we really don't know the earliest moments of cosmic time as the early history of the Big Bang is beyond the limits of our modern physics. In those early moments of the universe, the temperatures and plasma conditions were so extreme that our current science

[277] https://skyserver.sdss.org/dr1/en/proj/basic/universe/

[278] http://en.wikipedia.org/wiki/Initial_singularity

[279] Alexander Vilenkin, The Beginning of the Universe, 2015. https://inference-review.com/article/the-beginning-of-the-universe Vol. 1, NO. 4 / October 2015. DOI: 10.37282/991819.15.18

[280] http://en.wikipedia.org/wiki/Borde–Guth–Vilenkin-theorem

can only suggest possibilities based on extrapolations and these possibilities may not always be correct[281].

The present scientific belief is that at the beginning of the universe there was no space and no time. It is theorised that the universe began as a singularity of unknown size, possibly a densely packed ball that contained all the mass and energy of the present universe. The ball collapsed onto itself and then exploded, giving rise to the hot Big Bang.

TIMELINES

1. 10^{-43} seconds after the Big Bang (op. cit.) is known as the **Planck Epoch**, the earliest period in the history of the universe. The conditions at such an early stage of the universe are beyond the grasp of our present knowledge of physics. The only tool we have is the extrapolation of known physical laws to extreme high temperatures. At this time, the universe was extremely hot and made of dense plasma. All four fundamental forces - gravity, electromagnetic, strong nuclear and weak nuclear - were probably unified into one. Immediately after the Big Bang, the universe started expanding and simultaneously cooling off, although the temperature was still at trillions of degrees of Kelvin. When this hot soup was slightly cooled, the subatomic particles of quarks, leptons and possibly dark matter and dark energy appeared. It was expected that the subatomic particles included almost equal amounts of matter and antimatter, but most of it quickly annihilated each other. This left a small excess of matter in the universe. At this stage, electrons couldn't stay in orbit around any atomic nucleus because of the immense heat and extensive radiation. Even if any stable atom would form, it would be knocked apart again by energetic radiation[282]. Stable atoms contain the same number of protons and electrons, and thus carry no overall charge.

2. 10^{-38} to 10^{-34} seconds after the Big Bang[283] is known as the **Grand Unified Epoch**. During this time the universe expanded rapidly. The immeasurably hot and dense state of the Planck Epoch was followed by the separation of the four fundamental forces (op. cit.). First the strong nuclear force separated from the electromagnetic and gravitational forces. When the universe expanded and cooled, shortly after the electromagnetic and gravitational forces separated the temperature fell below what is referred to as the symmetry breaking point. The disordered but symmetric state of the universe collapsed, turning into an ordered but less symmetric state[284].

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[281] https://en.wikipedia.org/wiki/Chronology_of_the_universe

[282] Candy Ye and Alison Klesman https://astronomy.com/magazine/ask-astro/2018/12/the-first-element

[283] https://en.wikipedia.org/wiki/Chronology_of_the_universe

[284] Heylighen, Francis (2021-03-20). *"Entanglement, Symmetry Breaking and Collapse: Correspondences Between Quantum and Self-Organizing Dynamics". Foundations of Science.* Brussels, Belgium: 85–107 – via SpringerLink.

3. 10^{-36} seconds to 10^{-12} seconds after the Big Bang is known as the **Electroweak Epoch**. This was the time when the electromagnetic and weak nuclear forces separated and elementary particles began to form. As the universe's temperature continued to fall below 159.5±1.5 GeV (or 1.831×10^{15} ^{o}K), the electromagnetic, strong, weak, and gravitational forces took their present forms [285] and fundamental particles gained their expected masses. However, the temperature of the universe was still too high to allow for the stable formation of fundamental particles like protons or neutrons. Therefore, no atoms, atomic nuclei, or molecules were around. In fact, any composite particles that happened to form by chance were broken apart due to the extreme energies[286].

4. 10^{-12} seconds to several minutes after the Big Bang is known as the **Particle Creation Epoch**. During this time, neutrinos decoupled and primordial black holes were possibly formed. Subatomic particles formed including protons, neutrons, and electrons.

5. About two minutes after the Big Bang, around 25% of all the protons and neutrons fused into heavier elements, initially deuterium which itself quickly fuses into mainly helium-4 [(op. cit.)].

6. Around three minutes after the Big Bang, the temperature in the universe became too low for nuclear fusion to occur and the universe entered a period of darkness. The universe was no longer hot enough for nuclear fusion but it was still far too hot for neutral atoms to exist or photons to travel far distances. It is therefore simply opaque plasma [(op. cit.)]. Once the nucleosynthesis reactions ended, no further nuclei could form[287].

7. 370,000 or 380,000 years after the Big Bang is known as the **Cosmic Dark Ages or Opaque Period**. Then came the **Recombination Stage.** The neutral hydrogen (having one proton and one electron) formed. Once the neutral hydrogen atoms finished forming, the universe became transparent[288] for the first time. Newly formed atoms—mainly hydrogen and helium with traces of lithium - quickly reached their lowest energy state, referred to as ground state. This was done by the atoms releasing photons, a process referred to as photon decoupling. These photons can still be detected today as CMB radiation. This is the oldest direct observation we currently have of the universe. After the recombination era, the universe went opaque again[289].

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[285] D'Onofrio, Michela; Rummukainen, Kari (15 January 2016). "Standard model cross-over on the lattice". Physical Review D. *93 (2): 025003.* arXiv:1508.07161. Bibcode: 2016PhRvD..93b5003D. doi:10.1103/PhysRevD.93.025003. S2CID 119261776.

[286] https://en.wikipedia.org/wiki/Chronology_of_the_universe

[287] Candy Ye and Alison Klesman https://astronomy.com/magazine/ask-astro/2018/12/the-first-element

[288] Transparent universe means not an opaque universe. The universe is said to be opaque when protons and electrons were not combined and the photons (of all wavelengths), freely scattering around, whereas a transparent universe means those electrons and protons were combined and formed neutral hydrogen atoms. https://en.wikipedia.org/wiki/Reionization

[289] https://www.scienceabc.com/nature/universe/where-did-the-elements-come-from.html

8. 100 million years after the Big Bang is when the very early stars started to form. **The epoch of reionization** began as gas clouds collapsed to form the earliest stars (op. cit.).

9. 200 million years after the Big Bang is when primordial galaxies started to form. Then the galaxy clusters were formed as the largest structures in the universe. Massive galaxies contain black holes at the centre of each of thousands of individual galaxies (op. cit.).

10. Around 4.6-4.8 billion years after the Big Bang is when our Sun and solar system were born (op. cit.). Earth was formed 4.5 billion years ago.

VI.4. What Fills The Empty Space Of Our Universe?

We usually think that nothing can be created out of nothing because it would violate the law of conservation of energy which says that energy can neither be created nor destroyed. The concept of the universe forming from nothing does seem to provide us with a lot of answers, but it still clashes not only with common sense, but also with findings which show that the empty space (the vacuum) is a dynamic place from which pairs of virtual particles emerge and annihilate each other, converting into light energy and disappearing back into the vacuum.

Quantum field theory teaches us that all particles are represented by quantum fields. These fields constantly fluctuate in strength and energy, even in the absence of any particles. A vacuum is the state in which there are no particles present, but there are still fluctuations in the quantum field and therefore a vacuum is not truly empty - it is still a state with energy. This tells us that nothing must be something, and that something needs to be figured out.

If space is not empty, then what fills the empty space of our universe? There are some ideas both old and new, which will be discussed briefly below. The short answer to this question is that an unknown energy fills the empty space. It occasionally manifests its existence by briefly popping out virtual particles in pairs, like electrons-positrons, muons and antimuons, protons and antiprotons, and even quarks and antiquarks.

According to quantum field theory, the universe is not made of isolated particles but rather continuously fluctuating matter fields, whose quanta are leptons and quarks, and force carriers such as gluons, bosons and photons. All these fields have zero-point energy.

In the context of quantum field theory, vacuum states (or the lowest energy states of fields) also contain Zero Potential Energy (ZPE). Every field (such as electromagnetic, gravitational, or matter fields) has its own zero-point fluctuations.

Zero-point energy refers to the lowest possible energy that a quantum system may have. It is the energy that remains in a system even when it is at its lowest possible energy state, known as ground state. This energy arises due to the uncertainty principle of quantum mechanics, which states that the more precisely the position of a particle is known, the less precisely its momentum can be known, and vice versa. Therefore, even when a particle is at rest, it still has some kinetic energy due to the uncertainty in its position and momentum. This energy is known as zero-point energy.

The ZPE is a concept supported by experiments. The most direct experimental evidence of zero-point energy comes from the Casimir effect which confirmed the existence of attractive forces between uncharged conducting plates due to the zero-point energy of the electromagnetic field in the vacuum. This results from the restriction of zero-point energy modes between the plates, leading to a lower energy state compared to outside the plates.

The other evidence comes from the so-called Lamb Shift phenomenon: Quantum electrodynamics (QED) predicts that the energy levels of hydrogen atoms exhibit small shifts due to interactions with vacuum fluctuations, known as the Lamb shift. This phenomenon has been measured and confirms the existence of zero-point energy and its effects.

VI.4.A. AETHER FILLS THE UNIVERSE

In the early days, many philosophers and scientists intuitively believed that a medium, an aether, was necessary for light waves to travel, just like the waves of the ocean travel through the medium of water[290]. This view was held for about 2,000 years. The concept of aether was first proposed in ancient Greek philosophy. The idea was then revived in the 19th century, when physicists attempted to explain the wave-like nature of light.

Aether theories refer to various hypotheses in physics which propose the existence of an ethereal medium called aether that fills the entire universe. This hypothetical substance is thought to be the medium through which light and other electromagnetic waves propagate through the vacuum of space.

Aether even played a role in Einstein's General Relativity equations. These equations relate to equating the matter and energy in the Universe on the one side, and the curvature of space on the other. Einstein's later premature modification to this equation (referred to as Einstein's famous blunder) in 1917 was to add a cosmological constant - the parameter Λ - to the curvature of space

[290] Yuen Yiu, 2017. A Study About Nothing. https://www.insidescience.org/news/study-about-nothing

side of the equations, to make the universe remain static and eternal (Steady State), and avoid forming a dynamic universe.

Aether exists everywhere, yet it is invisible, weightless, undetectable, and has no effect on physical objects - almost as if it didn't exist at all[291],[292]. Aristotle called aether the fifth element in addition to fire, air, earth, and water.

In 1644, French philosopher René Descartes developed his mechanical theory of gravity, which said that empty space must not be empty at all and must be filled with something. Descartes believed that something was aether. He envisioned a dense, fluid medium that consisted of colliding particles that could transmit forces, including the mysterious force of gravity. He thought that as objects moved through the aether fluid, the displaced particles created vortices. According to him Earth was an immense aether vortex, circling around the sun[293].

Aether is seen as a physical medium occupying every point in space, including within material bodies. It is this medium which gave rise to the electric, magnetic, and gravitational potentials and determined the propagation velocity of their effects[294].

There are a few different versions of the aether concept including Newtonian aether, luminiferous aether, and gravitational aether. The Dutch scientist Christiaan Huygens proposed the popular hypothesis called luminiferous (light-bearing) aether, as a medium for the propagation of light. Nikola Tesla held onto this idea well into the 20th century, writing in 1938 that "*all attempts to explain the workings of the universe without recognizing the existence of a light-bearing aether are futile*"[295].

During the 19th Century, it was commonly assumed that matter was enveloped by an invisible substance that filled empty space, and this substance was all-pervasive aether. This meant that the movement of objects should require ploughing through the aether. This in turn should create a drag reaction in the aether, and that therefore the speed of matter through the aether must be measurable[296]. This view was tested by experiments known as the Michelson-Morley experiments in 1887. These experiments were unsuccessful and did not give a positive result, so the idea of a

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[291] The Eternal Quest for Aether, the Cosmic Stuff That Never Was (2021); https://www.popularmechanics.com/science/energy/a23895030 /aether/

[292] Friedwardt Winterberg, 2002. The Planck aether hypothesis: an attempt for a finitistic non-Archimedean theory of elementary particles. Paperback. September 1, 2002.

[293] Meg Neal (2021). The Eternal Quest for Aether, the Cosmic Stuff That Never Was. https://www.popularmechanics.com/science/energy /a23895030/aether/

[294] https://www.chemeurope.com/en/encyclopedia/Aether_theories.htmly

[295] Meg Neal (2021). The Eternal Quest for Aether, the Cosmic Stuff That Never Was. https://www.popularmechanics.com/science/energy/a23895030 /aether/

[296] https://www.chemeurope.com/en/encyclopedia/Aether_theories.htmly

stationary aether was effectively ruled out (op. cit.). The aether theory had dominated physics for over 1,000 years, but these failed experiments marked the end of it for a while.

The fallout of the Michelson-Morley experiments inspired others, such as Einstein's breakthroughs in relativity, and opened the door to modern physics[297].

In 2018 Georgy Nikolskiy[298] said "*The word 'aether' has gained a very negative connotation in theoretical physics. We do not speak about aether, because it's a taboo*".

French physicist Louis de Broglie proposed another revolutionary theory[299]. He found that electrons may also have properties of a wave, and that matter on an atomic scale has the same dual nature as light. This ground breaking hypothesis led to the theory of quantum mechanics, which also had no need for aether (op. cit.).

Quantum mechanics sealed the coffin of the aether idea. By the end of the 1920s, aether was discarded and considered outdated. But it didn't disappear. The term aether has lived on as a colloquial expression of the intangible void. Certain traditional cultures still consider aether the fifth element, and it is used in the obscure worlds of mysticism, magic, and the supernatural (op.cit.).

The quantum model of the vacuum, with all its fluctuations and peculiar features, has since been thoroughly tested and proven. We can see pair-creation all the time in particle accelerators. Experimental evidence shows all kinds of particles, muons and antimuons, protons and antiprotons, and even quarks and antiquarks, coming in and out of the vacuum. Vacuum space is definitely not empty, rather it is a vibrant and busy place - although not visible to the naked eye.

Einstein's Theory of Relativity did not disprove aether, but it did provide a simpler explanation which does not require a medium for the light to go through. This meant that aether wasn't needed as a fixed reference framework for the universe, because time and space were relative - part of one continuum. Space time was the new aether (op. cit.).

The universe addresses this by creating more energy storage silos. Firstly, by making increasingly heavier elements - heavier atoms have a higher energy storage capacity. For example, uranium, with an atomic number of 92 (92 protons or electrons), contains more potential energy than bituminous coal, made from carbon atomic number 6 (6 protons or electrons, as shown in figure

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[297] Meg Neal (2021). The Eternal Quest for Aether, the Cosmic Stuff That Never Was. https://www.pbslearningmedia.org/resource/phy03.sci.phys.energy.sprelativity/einsteins-special-theory-of-relativity/

[298] Georgy Nikolskiy (2018). The Charge Structures of Aether and Substance. Open Access Library Journal, 2018, Volume 5, e4379, ISSN Online: 2333-9721, ISSN Print: 2333-9705

[299] Meg Neal (2021). The Eternal Quest for Aether, the Cosmic Stuff That Never Was https://www.popularmechanics.com/science/energy/a23895030/aether/

below). Burning one kilogram of coal produces 8 kW of power per hour, while one kilogram of natural uranium generates 45,000 kW of power per hour[300].

Despite this setback, some physicists have continued to propose variations of aether theories in an attempt to explain certain unexplained phenomena in physics, such as the behaviour of gravity. However, with the development of modern theories such as relativity and quantum mechanics, the idea of aether as a fundamental medium for the universe has been completely abandoned by the scientific community.

VI.4.B. SPACETIME IS THE FABRIC OF THE UNIVERSE

In the standard model of the Big Bang, spacetime is the fabric of the known universe. The term spacetime was coined first by Hermann Minkowski, Einstein's former college teacher in mathematics. In 1906, soon after Albert Einstein announced his Special Theory of Relativity, Minkowski developed a new scheme for thinking about space and time that emphasised its geometric qualities[301].

Considering that space consists of three dimensions, and that time is one-dimensional, spacetime must therefore be a four-dimensional object (op. cit.). Spacetime is believed to be a continuum, because so far as we know there are no missing points in space or missing instants in time. Both space and time can be subdivided without any apparent limit in size or duration. Space and time are not separate entities, but are fundamentally intertwined.

Physicists now routinely consider that every celestial object is embedded[302] in this four-dimensional spacetime continuum, and that every event is described in terms of their location in spacetime and every particle is in this spacetime at a particular instant[303].

According to the spacetime continuum, the passage of time and the geometry of space are interrelated in such a way that the curvature of space is directly influenced by the presence of matter and energy. According to Einstein's General Theory of Relativity, gravity is a manifestation of the curvature of spacetime. It is a mathematical model that unifies the three dimensions of space and the one dimension of time. For example, the common two-dimensional depiction of spacetime is the dint made by the bowling ball to spacetime.

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[300] https://lowcarbonpower.org/type/nuclear

[301] https://einstein.stanford.edu/content/relativity/q411.html

[302] Gravity is often described as the warping of spacetime by energy and matter (like a bowling ball warping a trampoline)

[303] https://einstein.stanford.edu/content/relativity/q411.html

VI.5. Big Bang May Not Be the Ultimate Model to Explain the Origin of the Universe

The Big Bang theory has not been immune to criticism and questioning. One of them is how the universe could have been created out of nothing and from nowhere. There has also always been a lingering question of what was before the Big Bang. This is discussed in more detail in Section 7 of this chapter. [304],[305]

Dongshan et al., explained in mathematical terms[306] that the universe was born out of nothing, and that "nothing" was, in fact, a quantum vacuum fluctuation. As we discussed earlier, a quantum vacuum space is not “nothing,” as the void is not an empty space; virtual particles come in and out of existence over very short periods of time. So, "nothing," in fact, is something that we don’t yet fully understand.

Although the Big Bang theory still stands, its validity is increasingly questioned in light of astronomical data gathered by advanced space probes. For example [307], a recent finding of the James Webb Space Telescope is the existence of a multitude of massive galaxies that were formed 300 to 400 million years after the Big Bang. This finding was surprising because, according to the conventional Big Bang theory - accounting for dark matter, dark energy, normal matter, and radiation - galaxies require at least a billion years to form, grow, and evolve.

The James Webb Space Telescope has detected six massive ancient galaxies. These have been referred to as “universe breakers” by astronomers because their existence could overturn current theories. This is because these six galaxies were formed during a period when the universe was merely 3% of its present age [(op. cit.)].

These six galaxies hosted tens to hundreds of billions of stars the size of our sun, and their mass was on the order of the mass of our Milky Way galaxy. These findings are remarkable because such galaxy sizes are far larger than conventionally believed possible during such an early phase of the Big Bang. The findings indicate that the universe may have been awash with star formation far earlier than was first thought [(op. cit.)].

Scientists are now scrambling to find an explanation: Are some of the basic rules of cosmology wrong? Or can they discover a new mechanism to explain how such massive galaxies could form from small clouds of stars and dust at the dawn of time?

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[304] http://en.wikipedia.org/wiki/Initial_singularity

[305] https://www.forbes.com/sites/startswithabang/2018/07/27/there-was-no-big-bang-singularity/?sh=52ec8797d815

[306] Dongshan He, Dongfeng Gao, and Qing-Yu Cai, (2014). Spontaneous creation of the universe from nothing. http://arxiv.org/abs/1404.1207v1[gr-qc]

[307] James Webb Just Broke The Universe With This New Discovery - https://www.youtube.com/watch?v=h5Iir5LXItI

Questions have also been raised about whether it is possible for supermassive black holes at the centre of galaxies to heat up the surrounding gas, making these galaxies appear brighter and more massive than they really are. Others have raised the possibility that the galaxies are actually observed at a time much later than initially estimated, due to dust that causes the color of the light from the galaxy to redshift, giving the illusion of being further away in light-years and thus further back in time (op. cit.).

There is also the problem of dark matter. Some of these early galaxies contain nearly no dark matter, whereas others are almost entirely made up of dark matter. Data from the Hubble Telescope has shown that a galaxy known as NGC 1052 DF2 contained so little dark matter that its density is low enough for astronomers to look right through it (op. cit.). On the other hand, Chinese astronomers have discovered a dwarf galaxy 94 million light-years away from Earth, called Fast J01394328, which is composed of 98% dark matter. If dark matter is the *glue* that holds the fabric of the universe together, why doesn't it exist in consistent amounts? (op. cit.)

Some scientists have questioned the concept of singularity and suggested that the universe has no centre to account for singularity. If there was a bang of any kind, it would have happened everywhere at once - meaning it was a completely spontaneous event. Some galaxies seem to drift away from each other rather than from an imaginary central point in space.

The composition of the universe is also questioned. According to the Big Bang theory, the universe should consist of both matter and antimatter in equal amounts. However, we all know that antimatter is extremely rare in comparison to matter. How could this be possible if everything exploded from a single condensed ball of mass?

Some scientists believe the Big Bang could have just been a collision between a regular universe and an anti-universe, where time moves forward in the regular universe and time moves backward in the anti-universe. This idea partially draws on a 2004 discovery - the first thermal replica of CMB radiation. As the remnant of radiation emitted after the Big Bang, it should be more or less the same across all its parts. However, scientists quickly learned this was not the case; the centre axis of the universe boasts a huge stretch of above-average temperature. There are also cold spots and hot spots that disrupt the uniformity. One cold spot, in particular, is very large and has been shown to emit strange radio waves. Could this be the point where our universe intersects with another universe? Some scientists, including the late Stephen Hawking, say that it's very possible. At this point in time, the Big Bang theory is still the prevailing theory for how our universe began.

VI.6. WHY DO WE SUPPORT THE BIG BANG IDEA IN THIS BOOK?

You will see later in this book, in Chapter XI.3, that our own views to explain the origin of the universe need a hot, explosive Big Bang-like event. This is not because the Big Bang model finds support from redshift and CMB radiation evidence, but because the hot, explosive Big Bang provides the billions if not trillions of degrees in heat required to form quarks and electrons. We also favor the Big Bang because it provides the much-needed expanding space to lower the initial high temperatures, allowing quarks and electrons to combine (fuse) and form hydrogen, helium and some lithium atoms.

The Substrate model proposed in Chapter XI.3 also does not contradict the idea of a Big Bang resulting from the collision of two universes as suggested by the String Theory.

VI.7. WHAT WAS BEFORE THE BIG BANG?

The Big Bang is commonly thought of as the start of our universe about 13.8 billion years ago. But there are lingering questions like *what set off the Big Bang, and what were things like before the Big Bang?* We don't know for sure, but as always we have ideas, models, and hypotheses to answer such questions. The fact is that events taking place before the Big Bang are not observational, not measurable and therefore undefined. This contradicts the scientific method of finding answers because finding the correct answer to scientific problems requires testing even if it is by trial-and-error. So, the honest answer to the question: '*What was before the Big Bang?*' is that 'we do not know.'"

Any answer will only be speculation. Some answers will be semi-scientific ornamented with math and equations, some answers will be in the realm of science fiction like the fictional parallel universe of the Star Trek movies, and some answers will be either guesswork, a bit intuitive or far out.

The question of what was before the Big Bang is especially a tough one because if you do happen to come up with an answer, then you will get struck with another question of what was before that. To avoid falling into this trap, scientists came up with an idea to explain how the Big Bang popped out of nowhere, out of nothingness. A universe out of nothingness was a clever idea because if the universe forms out of nothing (from a singularity), then the universe does not need to expand into another space – because there will be no outside of the universe. Popping a universe out of nothingness would also provide an answer to the question of what was before the Big Bang. This

point of view is explained in detail in Lawrence M Krauss's book[308] entitled "*A Universe from nothing"*.

In Chapter XI, we also joined the speculator's bandwagon and proposed that another realm existed before cosmic inflation and the Big Bang. We refer to this space as the Substrate, from which our universe originated. Under this concept, we suggest that our universe, possibly along with others, grew in the Substrate that existed long before the Big Bang.

VI.8. ELEMENTARY PARTICLES AND FORCE FIELDS

Elementary particles were made during the very first seconds, during the Particle Creation Epoch, of the Big Bang[309]. They are also referred to as subatomic or fundamental particles. The first second after the Big Bang involved firstly the formation of quarks/antiquarks and leptons/antileptons as a dense ('*soup*') superfluid These were followed by the formation of protons, neutrons, radiation, and additional leptons/antileptons, and then eventually hydrogen and helium atoms. Altogether, the early stage of the Big Bang created 29 known fundamental particles and then those forces holding them, gluons, electromagnetic and nuclear as shown in **Table 1 and 2**. These are the building blocks of all the matter, both organic and inorganic. We call these particles fundamental because as far as we know at this point of time, they are not divisible nor they do not appear to be made up of smaller units of matter.

As shown in **Table 1 to 3**, fundamental particles can be grouped into two categories - fermions and bosons. Fermions are the basic building blocks of atoms and matter particles. They are the elementary components of everything in the universe. They make up everything we see on earth and the celestial objects in the night sky. There are two main categories of fermions - quarks and leptons. Whether a fermion is a quark or a lepton depends on the forces the particles experience or respond to.

Bosons transmit fundamental forces. They are classified into gauge bosons (photons, gluons, Z, W^- and W^+) and scalar (Higgs) bosons. Graviton is a theoretical, undiscovered particle and therefore shown as hypothetical in **Table 1.**

Both leptons and quarks are fermions that have spin numbers and obey the Fermi-Dirac spin statistics. Both have non-zero rest masses and have an antiparticle with a mass equal to the particle

[308] Lawrence Krauss, 2012. A Universe from Nothing – Why There is Something Rather Than Nothing. Free Press eBook and Simon & Schuster, Inc. ISBN 978-1-4516-2445-8; ISBN 978- 1-4516-2447-2 (ebook)

[309] https://www.sciencelearn.org.nz/resources/1727-how-elements-are-formed

mass. But there are some fundamental differences between leptons and quarks. For example, quarks interact only with other quarks via a strong nuclear force.

A strong nuclear force allows a quark to carry 3 different types of colour charges – green, red, and blue. This force is mediated by a boson known as gluon. A gluon carries colour charges and can interact with other gluons directly. Gluons have a combination of two-colour charge (one of red, green, or blue and one of antired, antigreen, or antiblue)[310].

Table 1. Fundamental particles of physics. Source: https://simple.wikipedia.org/wiki/Higgs_field

Elementary	**Fermions**	Quarks	up · down · charm · strange · top · bottom
		Leptons	Electron · Positron · Muon · Tau · Neutrinos
	Bosons	Gauge	Photon · Gluon · W and Z bosons
		Scalar	Higgs boson
Composite	**Hadrons**	Baryons / Hyperons	Nucleon (Proton · Neutron) · Delta baryon · Lambda baryon · Sigma baryon · Xi baryon · Omega baryon
		Mesons / Quarkonia	Pion · Rho meson · Eta meson · Eta prime · Phi meson · Omega meson · J/ψ · Upsilon meson · Theta meson · Kaon
	Others	Atomic nuclei · Atoms · Diquarks · Exotic atoms (Positronium · Muonium · Tauonium · Onia) · Superatoms · Molecules	
Hypothetical	Gravitino · Gluino · Axino · Chargino · Higgsino · Neutralino · Sfermion · Axion · Dilaton · Graviton · Majoron · Majorana fermion · Magnetic monopole · Tachyon · Sterile neutrino		

An electron (a lepton) can exist independently, but it also interacts with other electrons. This interaction is via a repulsive electromagnetic interaction, since all electrons carry the same negative coulomb charge. An electron can be removed from an atom by applying enough energy (up to a few tens of eV – electron volts). An electron is bound to an atom by a photon (another boson) via electromagnetic force.

When two spinning bodies like electrons, atoms, fermions and hadrons (baryons and mesons), come to a critical distance, a force field establishes. If one of the bodies has a bigger mass or higher energy level than the other, the force field is a gravity field. The greater the difference in mass or energy levels, the stronger the attraction will be. If the bodies have the same mass or energy levels,

[310] https://en.wikipedia.org/wiki/Color_charge

then no attraction takes place. The spin value of the force field above is an integer and can be zero, one and most probably two.

The critical distance changes from body to body, depending on factors such as their size, mass, or momentum. The force that holds quarks together is known as strong nuclear force. As quarks oscillate and spin within the nucleus of an atom, they generate waves of space that bind three quarks within a proton or neutron. The strong force operates at the quantum scale, outside of which the physical world has no effect[311].

The strong nuclear force is always attractive. However, electromagnetic forces can be repulsive due to the polarity of coulomb charges involved. The strong force which holds quarks is much stronger than the electromagnetic force. The force is so strong that quarks get confined inside the nucleon and cannot be liberated by applying even mega-electron-volts of energy to it. The application of extra energy just leads to the spontaneous creation of quark-antiquark pairs[312].

A quark also carries a coulomb charge but it is unlike the charge carried by a lepton. A lepton always carries either a whole number charge (such as an electron or a muon), or no charge (in the case of a neutrino). A quark on the other hand always carries a fractional coulomb charge. In the case of the up quark, this charge is +2/3 and for the down quark it is -1/3. In the case of a proton consisting of 2 up quarks and 1 down quark, it adds up to a +1 coulomb charge as measured experimentally. This is why a proton can interact with another proton via electromagnetic force, unlike a quark (op. cit.).

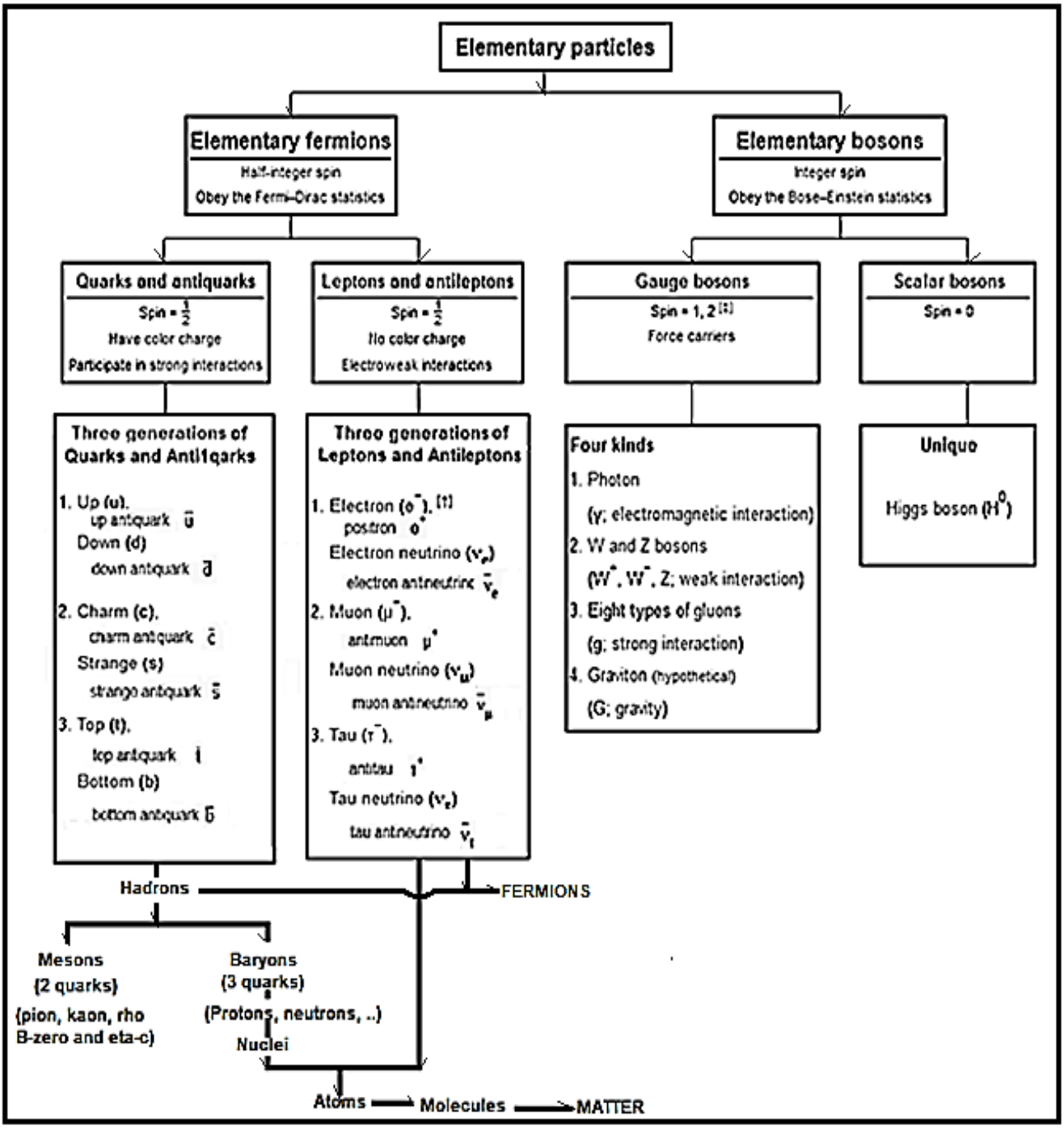
As shown in **Table 2**, quarks combine to form hadrons. The most stable hadrons are protons and neutrons.

These are components that make atomic nuclei. If there were no quarks there would be no hydrogen atom. There are six types of quarks, known as flavours: up, down, strange, charm, bottom, and top. Quarks come in pairs and make three generations.

[311] Amy Robinson and John Holland, October 10, 2011. Quantum Wave Theory - A Model of Unity in Nature. https://quantumwavetheory.wordpress.com/tag/quarks/

[312] Sanjay Sood What is the difference between a lepton and a quark? https://www.quora.com/

Table 2. Elementary particles make atoms and molecules which are the basic components of matter.

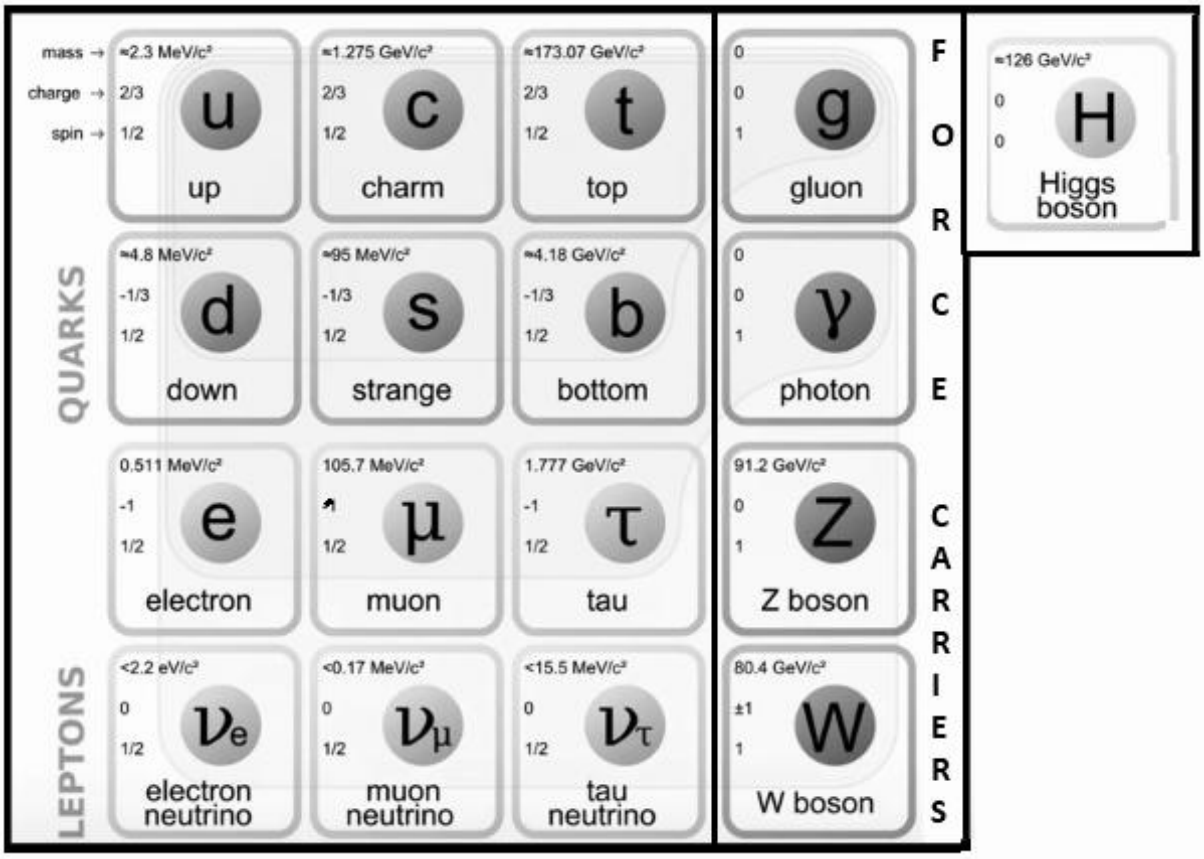


These are “up” and “down” (first generation), “charmed” and “strange” (second generation) and “top” and “bottom” (third generation). Among these only the up and down quarks are important because they make protons and neutrons. The others are stable only for a fraction of a second before decaying so they are too unstable to feature in ordinary matter. Every quark has its own antiparticle as shown in **Table 3**.

Two-quark hadrons are called mesons. They are composite particles made of one quark and an antiquark. Baryons are composite particles made of 3 quarks.

Fundamental particles differ from each other by their mass, spin, and charge differences as shown in **Table 3**, as well as by their response to the four forces of nature (gravity, electromagnetism, strong nuclear and weak nuclear).

Table 3. Table of fundamental particles – antiparticles of quarks are not shown.



There are 3 different kinds of force carriers: photons, gluons, and vector bosons. The photon is a massless and neutral elementary particle which mediates electromagnetism - the interaction between electrically charged particles[313]. Gluons are the force carriers of the strong interaction. Vector bosons are the gauge bosons - the force carriers of fundamental interactions: the photon of electromagnetism, and the W and Z bosons of weak interaction (op. cit.).

We know the forces acting between quarks are mediated by gluons so a gluon acts as the exchange particle for the strong force between quarks. It is analogous to the exchange of photons in the

[313] https://physicsmasterclasses.org/exercises/hands-on-cern/hoc_v21en/main_frame/sm_concl1.html

electromagnetic force between two charged particles[314]. Gluons and quarks bind together, forming protons and neutrons. All commonly observable matter consists of up quarks, down quarks, and electrons.

Quantum Chromodynamics (QCD) is the theory of strong interactions. It is an important component of the standard model[315] of the universe, and describes the interactions between quarks and gluons as they make protons or neutrons.

A photon is an elementary particle which is a quantum of the electromagnetic field. Electrons or protons respond to magnetic fields by bending when travelling through them. Quarks interact with gluon fields. The gluon field is very similar to the electromagnetic field, except gluons carry colour charge and therefore interact with each other as well as with quarks, unlike the photons of electromagnetism[316].

Electrons interact with photons as well as Z boson and W bosons[317]. Electromagnetism is the force which holds electrons in an atom. Electromagnetic forces arise from the exchange of virtual photons, where photon is the name given to a quantum or energy packet of the electromagnetic field[318]. Photons interact with electromagnetic force. Charged particles - such as electrons and protons - create electromagnetic fields when they move. These fields transport electromagnetic radiation or light. The electromagnetic field extends indefinitely throughout space.

Four Forces of Nature

The strong nuclear force keeps the nuclei of atoms together. Without it, every atom in the universe would spontaneously disintegrate. Gluons and quarks together form hadrons such as protons and neutrons.

The weak nuclear force is capable of converting protons into neutrons, and vice-versa, in a process known as beta decay. The weak nuclear force causes radioactive decay. It is transmitted by W and Z bosons[319]. In the 1960's, it was discovered that both the weak nuclear force and electromagnetism are deeply connected. They appear to be two different aspects of a single 'electroweak'

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[314] http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/color.html http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/color.html

[315] The Standard Model explains three of the four fundamental forces that govern the universe: electromagnetism, the strong force, and the weak force.

[316] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/gluon

[317] Cathal O'Connell, 2022. A primer to the theory of (almost) everything; A guide to the Standard Model of Particle Physics. https://cosmosmagazine.com/science/physics/particle-physics- standard-model/

[318] https://en.wikipedia.org/wiki/Electromagnetism

[319] Cathal O'Connell, 2022. A primer to the theory of (almost) everything; A guide to the Standard Model of Particle Physics. https://cosmosmagazine.com/science/physics/particle-physics- standard-model/

interaction[320]. At that time, it was predicted that the weak nuclear force would contain the W and Z particles. These particles were experimentally discovered in 1983 (op. cit.).

The Third force: Electromagnetism was discovered in the 19th century. Electric and magnetic fields in close proximity interact with, and influence, one another. Electricity and magnetism were eventually understood to be different aspects of a single force - electromagnetism. Electromagnetic force is responsible for much of what directly affects us, including the interactions between electrons and protons inside an atom, atomic interactions, and the molecular build-up and breakdown of material objects (op. cit.).

Gravity is the fourth fundamental force[321]. What creates the gravitational field of surrounding matter is not known to the present science although it is hypothesised that gravitational interactions are mediated by a yet undiscovered elementary particle, named graviton.

The only known Scalar Boson (spin zero boson) is the Higgs Boson (see Table 3). It is the second heaviest particle known today (120 mass units in GeV/c^2 units)[322]. This mass is more than 120 times that of a proton. The Higgs Boson has its own field known as the Higgs field, which fills the universe. Only particles with atomic mass interact with the Higgs field. Massless particles such as photons and gluons do not interact with the Higgs field. It is believed that Higgs field exists everywhere in space because of its high non-zero vacuum expectation value[323]. The Higgs boson mediates the interaction between the Higgs field and particles - such as electrons. Particles which interact with the Higgs field are given mass. Giving mass to a particle or an object is referred to as the Higgs effect.

The Higgs effect is like feeling the weight of your body in water when you swim due to drag, but not feeling its weight when you walk. Any massive subatomic particle moving in the Higgs field would feel its weight due to drag. A particle's mass determines how much it resists changing its speed or position when it encounters a force. This effect will transfer mass or energy to any particle which passes through the Higgs field.

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[320] Amy Robinson and John Holland, October 10, 2011. Quantum Wave Theory - A Model of Unity in Nature. https://quantumwavetheory.wordpress.com/tag/quarks/

[321] Graviton is a hypothetical particle associated with gravity.

[322] Third generation Top quark has the highest mass of 173.07 GeV/c2.

[323] https://home.cern/news/series/lhc-physics-ten/higgs-boson-what-makes-it-special

VI.9. HYDROGEN – THE COMMON ANCESTOR OF ALL OTHER ELEMENTS

Hydrogen is the first and the oldest element in the universe. It is also the lightest, the simplest (having just one orbit-one electron) and the most abundant element in the universe[324]. After theBig Bang, hydrogen (protium, ^{1}H) was the first isotope formed from one proton and one electron. An isotope is a variant of a chemical element which differs in the number of neutrons in its nucleus. This means that isotopes of the same element have the same number of protons but a different number of neutrons.

Hydrogen has two other isotopes, being deuterium (^{2}H) and tritium (^{3}H)[325]. Hydrogen isotopes are the building blocks for the formation of all other elements. Therefore, we may call hydrogen the common ancestor of every element formed through fusion and nucleosynthesis reactions.

The Big Bang created a universe containing about 75% hydrogen, 24% helium by mass and the rest being traces of lithium and the hydrogen isotope deuterium. The present universe still has approximately the same composition[326].

HOW DID HYDROGEN FORM FROM PRE-EXISTING PROTONS AND NEUTRONS?

Right after the Big Bang, radiant energy produced pairs of quark-antiquarks, electron-positrons, and other particle-antiparticles. As the particles and antiparticles collided in high energy plasma gas, they annihilated each other which released electromagnetic energy as photons. As the universe expanded, the average energy of radiation dropped. But particle creation and annihilation continued, until the temperature cooled enough that pair creation became no longer energetically viable. At this stage, the quarks and electrons had only a momentary existence. This is because annihilation removed them just as fast as they were created. As the universe cooled, quarks condensed into nucleons. This is when top and down quarks were formed.

The Big Bang created a soup of quarks and electrons. At extremely high temperatures, their random thermal motions were greater than the forces wanting to pull them together, so the universe stayed as a soup. Only when the soup cooled a little bit, protons and neutrons started to form. Protons formed from two up quarks and one down quark, and neutrons formed from one up quark and two down quarks.

Protons with a longer half-life (which is on average 10^{34} years)[327] quickly become dominant over neutrons with a shorter half-life (which is on average only 13.3 minutes). Under these conditions,

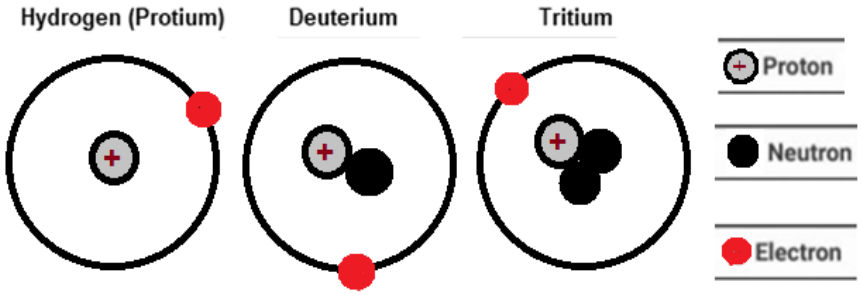
[324] Wojciech Grochala, 2015. 'First there was hydrogen' (Nature Chem. V. 7, p. 264), https://www.nature.com/articles/nchem.2186

[325] https://geol105.sitehost.iu.edu/images/gaia_chapter_1/primordial_deuterium.htm

[326] https://en.wikipedia.org/wiki/Nucleosynthesis

the thermal energy was still so great that no electron could stay associated with a proton in order to form a hydrogen atom.

As the universe expanded, it cooled and thermal energy dropped below the ionisation energy of hydrogen. An electron encountering a proton would radiate a photon, and drop into an orbit around the proton so that a neutral hydrogen atom formed. The orbit of the electron is determined when the electron falls into the electrostatic well around the proton. It falls until it can't fall any further, and then just occupies the lowest energy level around the proton. Occasionally the electron is kicked out of the orbit if it is struck by a photon, but otherwise the atom will remain as neutral hydrogen. The earliest hydrogen atoms were the three isotopes, protium (^{1}H), deuterium (^{2}H) and tritium (^{3}H)[328]. Various fusion processes[329], fission[330], and radioactive decay[331] type nucleosynthesis reactions then produced the heavier atoms of the Periodic Table.



Deuterium is a stable isotope of hydrogen, which unlike protium, also contains a neutron. Tritium is radioactive as it contains two neutrons, neutrons are chargeless particles.

The simplest form of hydrogen is protium (^{1}H). It does not have a nucleus, as it has only one proton and a single electron, but no neutron. Hydrogen has two other isotopes, one being the stable deuterium (^{2}H) which has one neutron, and the other being the radioactive tritium (^{3}H), which has two neutrons.

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[327] Proton decays into a positron and a neutral pion that itself immediately decays into two gamma ray photons. Photons do not decay into another particle; they are the least energetic baryons.

[328] https://geol105.sitehost.iu.edu/images/gaia_chapter_1/primordial_deuterium.htm

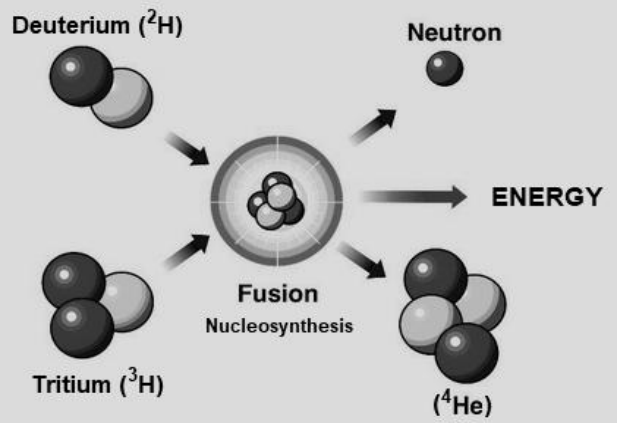
[329] Nuclear fusion is the fusing of two light atomic nuclei into one heavier nucleus. Nuclear fusion requires high energy in order to be ignited. For this reason, nuclear fusion only occurs right after the Big Bang, at the cores of sizable stars and during supernovae explosions. Nuclear fusion processes produce elements up to iron.

[330] Nuclear fission is the splitting of one large atomic nucleus into smaller fragments. Nuclear fission also requires high energy or a large mass of heavy, radioactive elements. Significant nuclear fission reactions occur only during supernovae explosions.

[331] Radioactive decay is the change of a less stable nucleus to a more stable nucleus. Radioactive decay happens automatically to unstable nuclei and is therefore much more common. Nuclei with too many neutrons, too few neutrons, or that are simply too big are unstable and decay to a stable form .

The proton which builds hydrogen's isotopes is made of two up quarks and one down quark. These particles are bound together with a strong nuclear force. The neutrons of deuterium and tritium are also made of quarks, but have one up quark and two down quarks.

Nucleosynthesis reactions start with the fusion of hydrogen isotopes - protium-protium and deuterium-tritium[332] as shown in figure below. These fusion reactions release large amounts of heat and radiation (kinetic energy) and neutrons. The fusion of deuterium and tritium produces a helium atom, a high energy neutron and releases 17.6 MeV of energy[333]. Note that the released energy is originally sourced from the Big Bang in the making of hydrogen isotopes, and therefore no new energy is added to the newborn universe.



The fusion of deuterium and tritium in a laboratory on Earth needs temperatures over 100 million degrees Celsius and intense pressures[334]. The Big Bang provided extreme temperatures, over 1000 trillion degrees Celsius, so high that no additional pressure was needed to overcome the Coulomb Barrier between these two positive nuclei and bring them close enough to undergo a fusion reaction.

The fusion reaction releases the energy which binds electrons to nuclei and the first-generation quarks of protons and neutrons. This is because the total mass of the resulting single nucleus is less than the mass of the two fusing nuclei, and the leftover mass becomes energy. Part of the existing kinetic energy of the Big Bang is converted to a new mass, and the neutron and energy released from this reaction are consumed elsewhere.

Protium ^{1}H burning reactions like the $^1H + {}^1H \rightarrow {}^2He$ + ENERGY reaction are happening at the core of our Sun all the time. The energy released from this reaction is partially consumed on Earth and other parts of the Solar System by biosphere, atmosphere, hydrosphere, and lithosphere. This is done in various ways such as by heating rocks, air and oceans, and making grass and trees grow.

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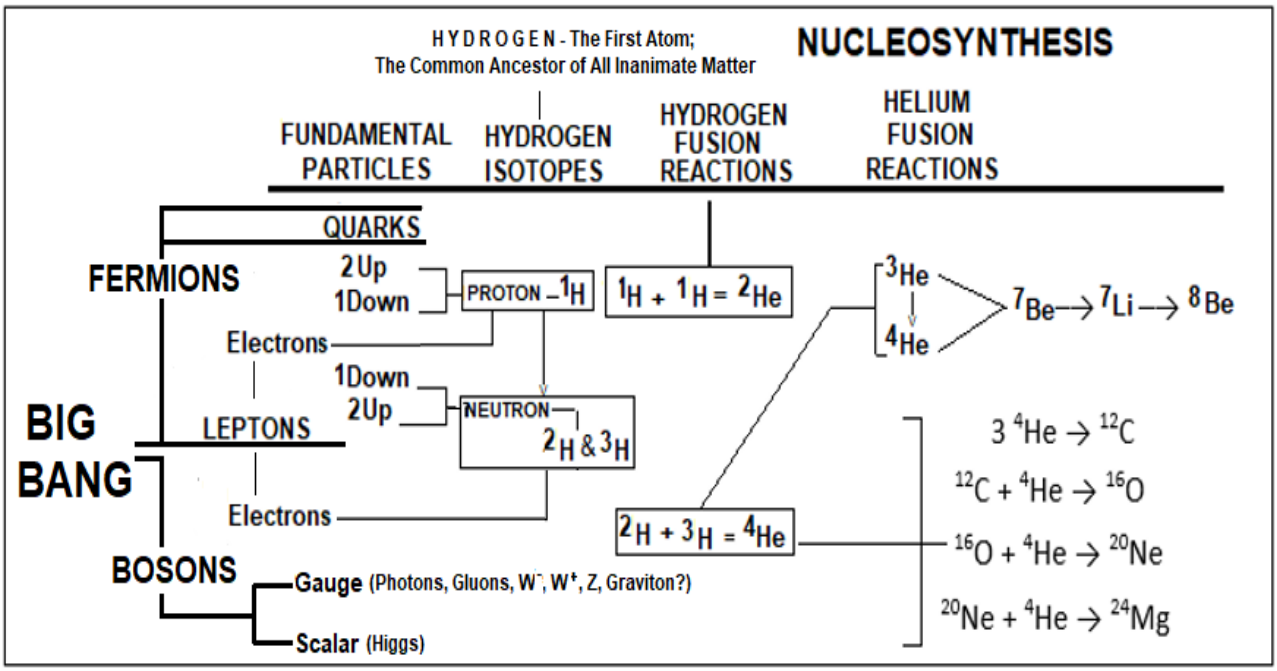
[332] Hydrogen Fusion: http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/procyc.html

[333] http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fusion.html

[334] https://www.iaea.org/bulletin/what-is-fusion-and-why-is-it-so-difficult-to-achieve

The simplest form of nuclear fusion is the fusion of two hydrogen atoms to produce a helium atom (See figure below). We see this from our Sun and other stars.

This is a stepwise reaction where reaction takes place through a series of individual steps or stages. In this case the first reaction includes the formation of a highly unstable diproton (^{2}He isotope, helium with two protons but without any neutron), then deuterium, and then ^{3}helium and then ^{4}He. Each reaction is associated with a release of substantial amounts of energy. ^{3}He fuses with a pre-existing ^{4}He, which produces a beryllium-7 isotope (^{7}Be). This then decays to a lithium-7 isotope (^{7}Li), which then fuses with another proton to make ^{8}Be.



Hydrogen is the first element in the universe. After the Big Bang and before the appearance of hydrogen isotopes, there were fundamental particles like quarks and leptons, and fundamental forces bound these particles together. The elements of the periodic table started to form by fusion reactions between the isotopes of hydrogen and then helium, and then hellium and carbon (see carbon cycle below).

Helium burning reactions produce other elements including[335]:

The fusion of three helium atoms gives a carbon atom: $3\ ^{4}He \rightarrow\ ^{12}C$

The fusion of a carbon atom with a helium atom gives an oxygen atom: $^{12}C + ^{4}He \rightarrow\ ^{16}O$

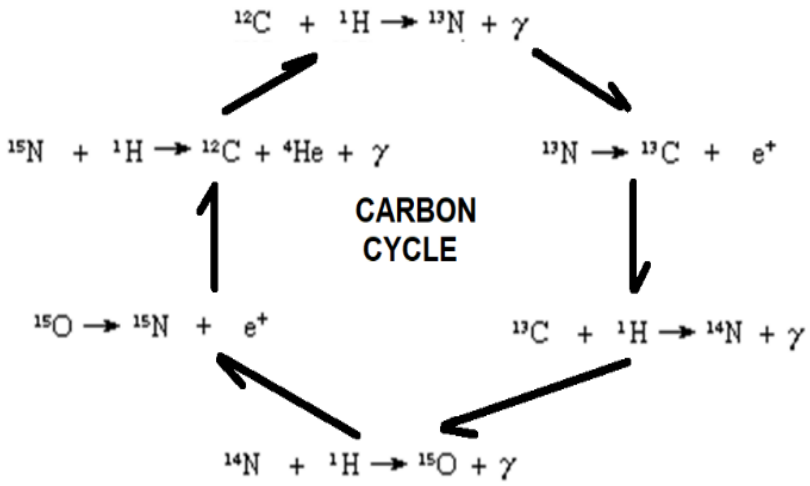
The fusion of an oxygen atom with a helium atom gives a neon atom: $^{16}O + ^{4}He \rightarrow\ ^{20}Ne$

The fusion of a neon atom with a helium atom gives a magnesium atom: $^{20}Ne + ^{4}He \rightarrow\ ^{24}Mg$

[335] https://www.sciencelearn.org.nz/resources/1727-how-elements-are-formed

Some of the ^{12}C produced from the fusion of three of the helium atoms can also fuse with protium to form ^{13}N. One of the protons then decays with the emission of a positron and a neutrino[336] to form ^{13}C. Two more protons than produces ^{14}N and then ^{15}O. The decay of another neutron leaves ^{15}N. The capture of another proton produces ^{16}O which emits an energetic alpha particle to return to ^{12}C to repeat the cycle (op.cit.). This proton induced burning of carbon, nitrogen, and oxygen, through the carbon cycle is known as C-N-O bi-cycle.

These reactions still take place today at the cores of all sizable stars. Stars are the factories that produce nearly all the elements of the periodic table as discussed later in this chapter.


$^{12}C + {}^{1}H \rightarrow {}^{13}N + \gamma$
$^{13}N \rightarrow {}^{13}C + e^{+}$
$^{13}C + {}^{1}H \rightarrow {}^{14}N + \gamma$
$^{14}N + {}^{1}H \rightarrow {}^{15}O + \gamma$
$^{15}O \rightarrow {}^{15}N + e^{+}$
$^{15}N + {}^{1}H \rightarrow {}^{12}C + {}^{4}He + \gamma$
CARBON CYCLE

The Carbon Cycle.

Despite billions of years and countless stars fusing hydrogen into helium, it still makes up 75% of the detectable content of the universe[337], including us. Close to two-thirds of the atoms in our bodies are hydrogen, in the form of water and in organic molecules like fats and proteins. It is the substance which allowed life to emerge on Earth in an aqueous environment. Therefore, hydrogen is essential for the existence of life on Earth.

Hydrogen is also important for numerous chemical reactions, as it can be at different valence states or oxidation states including −1 (hydride), 0 (elemental), and +1 (proton), each with very different physicochemical properties.

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[336] http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/carbcyc.html#c1

[337] Hydrogen - Element information, properties and uses; Royal Society of Chemistry: https://www.rsc.org/periodic-table/element/hydrogen

The H_2 molecule is quite inert, although ionised hydrogen (the H^- anion) is a very strong base and a strong reducing agent. The H^+ proton is a strong acid and a powerful oxidizer. Note that nuclei more massive than ^4He and ^7Li were not made in the Big Bang, because the densities and energies of the particles were not big enough to initiate further nuclear reactions.

VI.10. The Formation of Stars And Black Holes

About a billion years after the Big Bang, cold atomic hydrogen and helium gas began to be drawn together to collide with each other under the influence of their mutual gravitational forces to form dense gas clouds. These clouds warmed as they contracted and aggregated to higher densities. When the temperature of the hydrogen gas reached a few million Kelvin, nuclear reactions began in the cores of these protostars. More massive elements then began to form in the cores of these very massive stars, which eventually became the stars as we know today.

Gravitational pull towards the centre of a star creates massive amounts of heat and pressure, from friction and numerous nuclear reactions and radioactive transformations. The immense heat generated this way creates an outward pressure, so that the newborn star does not collapse onto itself too quickly. The heat is generated by a fusion process called hydrogen burning, which produces energy, helium and a small amount of lithium.

Further nucleosynthesis reactions create the heavier elements of the Periodic Table. The heavier elements gradually sink to the core, and a state of core collapse begins. With each new stage of elemental fusion, the core of the star becomes increasingly denser, and the outer layers of the star expand dramatically - several hundred times beyond the former size of the star. The colour of the star turns from its initial white-yellow colour into a red colour, giving these types of stars their name - Red Giants.

A Red Giant forms after a star has run out of hydrogen fuel to power nuclear fusion reactions. A star becomes unstable when the fine balance between its own gravity, which holds it together, and the outward pressure from ongoing thermonuclear fusion processes taking place at its core, is destroyed[338].

Stars roughly equivalent to the mass of our Sun can produce elements above helium only after turning into a Red Giant. This is because their cores are not hot enough. However, the cores of massive stars act like furnaces and they are the perfect place for the fusion of nuclei heavier than helium to generate energy[339]. These reactions go on to make all the elements on the Periodic Table

[338] https://esahubble.org/wordbank/red-giant

[339] https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch23/fission.php

up to silicon. Except for boron and beryllium, which are not formed in a star, but are instead formed by cosmic ray fission[340].

The final stage of the evolution of stars is when silicon begins to burn. Once the core of the star starts fusing silicon to iron, the core has no more nuclear reactions to fight against gravity. This is because iron has the most stable nucleus in the universe, and fusing it to something heavier requires the input of energy – it does not release energy. This signifies the beginning of the end of the massive star's life[341].

When the core of the star has only iron and traces of nickel left, it becomes so dense that it starts collapsing in on itself. In the final few seconds as the core continues to collapse, all the atoms get squeezed against each other. This creates a colossal amount of energy and pressure. At this point the star suddenly and catastrophically explodes and ejects most of its mass into space. This is called a supernova explosion.

Elements heavier than iron and some isotopes of lighter elements may be accounted for by successive neutron capture processes. The capture of a neutron increases the mass of a nucleus, and subsequent radioactive beta decay converts a neutron into a proton (with ejection of an electron and an antineutrino), leaving the mass practically unchanged[342]. The increase in the number of protons builds the nucleus to higher atomic numbers.

When a massive star explodes into a supernova, it releases a huge amount of energy and heat reaching billions of Kelvin degrees. It also releases a very dense cloud of neutrons. This sets off a series of new reactions - neutron capture (r- and s-types) and proton capture reactions - where the rest of the elements of the Periodic Table form up to uranium, and including curium, californium and fermium. The fast neutron capture process is called the r-process (or rapid process), which takes place in less than a second. The r-process generates rare elements like gold, platinum, and silver[343].

The neutron capture also takes place at a slower rate, which is also known as the s-process (or slow process). The s-process produces elements heavier than copper, by the slow absorption of neutrons by atomic nuclei. The capture of neutrons in the s-process occurs over time scales of thousands of years – long enough to allow unstable nuclei to decay via emission of a beta particle, before

[340] Nuclear fission is a reaction in which the nucleus of an atom splits into two or more smaller nuclei.

[341] https://www.scienceabc.com/nature/universe/where-did-the-elements-come-from.html

[342] https://Britannica,com/science/nucleosynthesis

[343] Gold, platinum and silver extracted from ground in Australia, Canada, and South Africa are concentrated form of these elements by geological processes.

absorbing another neutron. The s-process elements include barium, zirconium, yttrium, and lanthanum[344, 345].

Besides the neutron capture reactions, there are also proton capture (p-process) reactions which take place. In the p-process, an atomic nucleus and one or more protons collide and merge to form an even heavier nucleus[346].

The fission or fusion of iron group elements absorbs a dramatic amount of energy - like the footage of a nuclear explosion played in reverse. If the temperature increase from gravitational collapse is high enough to fuse iron, then the almost instantaneous absorption of energy will cause a rapid collapse to reheat and eject a huge number of neutrinos[347,348].

The elements expelled into space after the death of a star eventually form new stars, planets and moons. After those new stars die, the matter is again returned to the cosmos. This cycle continues over and over all the time. The universe is really quite like an enormous recycling bin - it recycles and reuses every piece of matter that was once created. Through these events, millions of galaxies, stars, and planets have been formed and will continue to form, using the same primordial matter that was left over after the Big Bang[349].

BLACK HOLES

Black holes usually cannot be observed directly on account that they do not emit light; however, they can be "observed," by the effects of their enormous gravitational fields on nearby matter due their enormous mass. It is believed that a black hole is a region in space where an enormous amount of mass is packed into a tiny volume, creating a gravitational pull so strong that nothing could escape the grasp of its gravity. Yet, we currently scientists do not know with certainty what is inside a black hole. What is this enormous mass composed of? How is such an enormous amount of mass or energy packed into that tiny space, singularity? Where did this enormous amount of mass originate? Yes, there are some ideas and answers to these questions, but these are largely untestable with our present technologies. We lack knowledge about what is inside a black hole because these celestial objects are beyond the laws of our physics.

Although so much mystery surrounds them it is established that they are real and physically exist.

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344 https://www.daviddarling.info/encyclopedia/S/s-process.html

345 https://en.wikipedia.org/wiki/S-process and https://en.wikipedia.org/wiki/r-process

346 https://en.wikipedia.org/wiki/Proton_capture

347 http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

348 *Annual Reviews. Astron. Astrophys. 1994. 32: 153-90* https://ned.ipac.caltech.edu/level5/Sept01/Meyer/Meyer5.html

349 https://www.scienceabc.com/nature/universe/where-did-the-elements-come-from.html; and https://en.wikipedia.org/wiki/Nucleosynthesis

John Michael, a humble rector from an English country town, is thought to have proposed the concept of black holes in 1738. The idea of black holes, known as "frozen stars" in the early days, was rediscovered in 1916 after Einstein published his theory of gravity[350] Karl Schwarzschild developed the idea of black holes from the equations of General Relativity in 1916; just a year after Einstein published his theory[351]. According to Schwarzschild, based on general relativity, the gravitational collapse of a sufficiently compact mass would form a singularity, or so-called Schwarzschild black hole. However, Schwarzschild himself made it clear that he believed the theoretical solution was physically meaningless, emphasising that he did not accept the physical reality of black holes. However, since then the existence of black holes has been proven by astronomical (gravitational waves) observations.

The work of Robert Oppenheimer and others led to the idea that such an object might be formed by the collapse of a massive star. The term “black hole“ was itself coined in 1967 by the Princeton physicist John Wheeler, who worked out further details of a black hole’s properties (op.cit). Black holes are real stellar objects of varying sizes found at the centres of nearly all galaxies. Those black holes at the centres of the galaxies characteristically have a red-hot outer rim called the event horizon beyond which nothing, including light, can escape due to the overwhelming gravitational pull of the singularity at the core of the black hole. Most of our observable knowledge about the black holes comes from the event horizon.

Black holes lack any characteristics beyond their mass, angular momentum (spin) and their electric charge. It is generally agreed that the prevailing temperatures are freezing cold inside, nearly absolute zero Kelvin[352], but glowingly hot at the event horizon. For comparison, the internal temperature of a black hole with the mass of our Sun is around one-millionth of a degree above absolute zero or -273.15 degrees Celsius[353]. Supermassive black holes are even colder (op.cit.) and even more extreme.

We currently do not know with certainty what is inside of a black hole[354] other than claiming (theoretically) that there is a point of singularity at its centre. As objects, including stars, planets, or even gas and dust particles, enter the black hole's event horizon, they are supposedly accelerated

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[350] COSMIC HORIZONS: ASTRONOMY AT THE CUTTING EDGE, *edited by Steven Soter and Neil deGrasse Tyson, a publication of the New Press. © 2000 American Museum of Natural History.* https://www.amnh.org › cosmic-horizons-book › john-m…

[351] Jeremy Schnittman (2019). A brief history of black holes. https://www.astronomy.com/science/a-brief-history-of-black-holes/

[352] https://www.asc-csa.gc.ca/eng/astronomy/fact-sheets/black-hole.asp

[353] Canadian S[ace Agency: https://www.asc-csa.gc.ca/eng/astronomy/fact-sheets/black-hole.asp

[354] https://skyserver.sdss.org/dr1/en/proj/basic/universe/

towards the centre of the black hole and are stretched and compressed in a process called "spaghettification".

At the theoretical point of singularity, the gravitational forces become so strong that spacetime itself is infinitely curved, and the current laws of physics break down. Some theories suggest that large amounts of matter creates the singularity, which occurs when this matter is crushed into a tiny point of infinite density. It is claimed that, for example, a large rock or boulder could theoretically turn into a black hole if squeezed immensely. Currently, it is believed that under immense pressure, the atoms of the boulder will break apart, with electrons and gluons torn into smaller fragments, which then disintegrate further into presently unknown sizes, potentially creating a black hole of incredibly small size[355].However, the mass and gravitational effects of the boulder will remain behind as an extreme distortion of the spacetime around it. This distortion of spacetime is what constitutes the black hole[356].

Stellar Black Holes have measurable parameters such as mass, energy, angular momentum, spin, and charge; these properties are inherent to their creation from a collapsing massive star. If the dying star possessed angular momentum or charge before it collapsed, the resulting stellar black hole would also retain these properties unless they were lost during the collapse. In essence, stellar black holes retain the masses and spin rates they were born with.

The prevailing theory is that black holes form from the collapse of very massive stars at the end of their lives. When a massive star exhausts fuel in its core, it can no longer produce enough energy to counteract the inward pull of gravity. The core begins to collapse under its own weight, generating enormous heat and pressure within the core. This process triggers a cataclysmic explosion known as a supernova, which ejects much of the star's outer layers into space. If the core is massive enough, the pressure and density become so extreme that the dead star collapses into a black hole.

Another way black holes are thought to form is through the collision of two neutron stars or through the accretion of matter onto a compact object such as a neutron star or white dwarf, which can then collapse into a black hole.

Primordial black holes[357] are thought to have formed shortly after the Big Bang, making them only a little younger than the Big Bang itself, roughly 400 million years old[358, 359]. The very earliest galaxies

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[355] The Physics of Black Holes - with Chris Impey; Lecture in Royal Institute. https://www.youtube.com/watch?v=roM1QPr8lNo

[356] https://lweb.cfa.harvard.edu/seuforum/bh_whatare.htm

[357] Gibney, E. (2015). Astronomers claim the first glimpse of primordial stars. Nature, 522, 401-402. https://doi.org/10.1038/nature.2015.17802. Or http://arxiv.org/abs/1504.01734 .
Nola Taylor Redd, 2011. Primordial star shouldn't exist - but there it is: https://www.nbcnews.com/id/wbna44346476
Michael Irving, 2021. Colossal primordial stars may have seeded supermassive black holes. https://newatlas.com/space/primordial-stars-may-have-seeded-supermassive-black-holes

[358] https://www.space.com/astronomers-find-first-evidence-of-heavy-black-hole-seeds-early-universe

in the universe cannot be observed with ordinary telescopes and require a high-tech telescope like NASA's James Webb Space Telescope.

Another explanation for the formation of primordial (very early) black holes is provided by late Stephen Hawking[360]. According to Hawking, primordial black holes are random high-density zones and can vary in size and shape. In 1971, Hawking proposed that such ancient black holes formed in the chaotic environment of the earliest moments of the Big Bang - a state of extremely high temperatures and density in which the universe originated 13.8 billion years ago, well before the first stars came into existence. These were so-called mini black holes, possibly with a mass equal to or less than that of a moon or an asteroid. At this stage of the universe's formation, pockets of Planck-sized subatomic particles could spontaneously reach the densities needed to create black holes.

There are also claims[361] suggesting that black holes are the source of dark energy which counts for the missing 70% of the universe. Crocker et al (2021)[362] proposed that things with mass, including black holes, may be coupled to cosmological expansion so that they slowly gain mass as the universe expands. This is similar to the coupling which causes light to be redshifted as the universe expands. Crocker et al supported their hypothesis with black hole merger data from gravitational wave observations.

All black holes have mass ranging from about 10 times the mass of our Sun (typically stellar black holes, the most common type) to millions or even billions of times more massive than the Sun (typically supermassive black holes), which are found at the centre of most galaxies.

According to the Quantum Wave Theory (QWT) of Robinson and Holland (2011),[363] a black hole is an area of total maximum space quantum compression. Space quanta in a black hole cannot vibrate

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[359] Gibney, E. (2015). Astronomers claim the first glimpse of primordial stars. Nature, 522, 401-402. https://doi.org/10.1038/nature.2015.17802. Or http://arxiv.org/abs/1504.01734 .
Nola Taylor Redd, 2011. Primordial star shouldn't exist - but there it is: https://www.nbcnews.com/id/wbna44346476
Michael Irving, 2021. Colossal primordial stars may have seeded supermassive black holes. https://newatlas.com/space/primordial-stars-may-have-seeded-supermassive-black-holes

[360] https://www.space.com/testable-primordial-black-holes-theory

[361] The Astrophysical Journal Letters (2023). DOI: 10.3847/2041-8213/acb704. iopscience.iop.org/article/10. ... 847/2041-8213/acb704
Duncan Farrah et al, A Preferential Growth Channel for Supermassive Black Holes in Elliptical Galaxies at z ≲ 2, *The Astrophysical Journal* (2023). DOI: 10.3847/1538-4357/acac2e
https://phys.org/news/2023-02-scientists-evidence-black-holes-source.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter
https://physicsworld.com/a/cosmological-coupling-is-making-black-holes-bigger-study-suggests/

[362] Kevin S. Croker et. Al., (2021). Cosmologically Coupled Compact Objects: A Single-parameter Model for LIGO–Virgo Mass and Redshift Distributions. The Astrophysical Journal Letters, Volume 921, Number 2. https://iopscience.iop.org/article/10.3847/2041-8213/ac2fad

[363] Amy Robinson and John Holland, October 10, 2011. Quantum Wave Theory - A Model of Unity in Nature. https://quantumwavetheory.wordpress.com/

as there is no room for rebound, no path of least resistance. The inside of a black hole is only uniform resistance. According to them, all space quanta inside a black hole are in the same state: that of maximum compression.

There are some doubts about the idea that black holes are the dense, remaining cores of massive stars left from supernova explosions. Remnants of a dead star are supposed to contain detectable elements like iron and nickel, particularly in their glowing boundary zone (event horizon). So far, no black hole has been found to contain iron and nickel. Some scientists explain[364] that "*the extreme gravity tears apart every iron and nickel atom and crushes them to become all subatomic particles or dense, compact Planck size mass*". This explanation does not hold up because gravity supposedly cold-fuses and transforms iron and nickel into an alloy or an unknown matter at near absolute zero temperatures, instead of pulling them apart. Such a disintegration process still needs to be demonstrated both theoretically and in the lab.

Most massive black holes are found at the centres of the galaxies, but smaller galaxies may not have a black hole at their centre. Over the last two decades, astronomers have found supermassive black holes with billions of solar masses formed shortly after the Big Bang. The James Webb Space Telescope[365] has discovered the most distant and earliest supermassive black hole, located at the heart of the galaxy CEERS 1019**.** It has a mass 9 million times greater than that of our sun, yet it was formed just 570 million years after the Big Bang.

Supermassive black holes become a concern when they are observed in the early universe, with masses already billions of times greater than our sun. There must be some mechanism that allows them to rapidly gather mass and grow to such giant sizes. Yet all existing mechanisms for this growth suggest that this process proceeds too slowly for such objects to exist so soon after the Big Bang.

With each new discovery, supermassive black holes have become more common in the relative infancy of the universe, thus With each new discovery, supermassive black holes have become more common in the relative infancy of the universe, thus increasing the urgency to find a mechanism to explain how they got there[366]. This concept became contrary to the Eddington limit,[367] which says that it should take black holes billions of years to gradually accumulate enough matter to reach supermassive black hole status. The faster a black hole consumes matter, the faster it grows. The quicker it grows,

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[364] https://astronomy.stackexchange.com/questions/26572/what-does-a-black-hole-elements-consists-of

[365] Webb Telescope Detects Most Distant Active Supermassive Black Hole, UT News, [2023], https://news.utexas.edu/2023/07/06/webb-telescope-detects-most-distant-active-supermassive-black-hole/

[366] https://www.space.com/supermassive-black-hole-growth-after-big-bang; How did supermassive black holes get so big so fast just after the Big Bang?

[367] J. A. Regan., T. P. Downes., M. Volonteri., et al, Super-Eddington Accretion and Feedback from the First Massive Seed Black Holes, [2018], https://arxiv.org/abs/1811.04953

the more electromagnetic radiation is blasted out by its surroundings[368]. If the electromagnetic radiation emitted from the black hole in the form of jets is intense enough, it can physically push material away. This means the faster a black hole consumes matter, the more likely it is to have the supply of that matter interrupted and pushed away, thus halting the growth of the black hole[(op. cit.)].

VI.11. GALAXIES AND DARK MATTER

GALAXIES

Soon after the Big Bang, the universe was filled with a nearly uniform soup of hydrogen and helium from which stars formed. A large collection of stars, gas, planets, moons, dust, and dark matter held together by gravity formed galaxies.

Galaxies are thought to have formed through a process called hierarchical clustering. This process involves the merging of small, compact objects called protogalaxies, which were composed of gas and dust. As the protogalaxies merged, their gravitational interactions caused them to grow in size and complexity, eventually forming the galaxies we observe today.

It is believed that clustering formed from small fluctuations or ripples in the dense soup of plasma which existed in the universe soon after the Big Bang. These fluctuations grew over time as matter was drawn together by gravity, eventually forming dense clumps that became the sites for the formation of galaxies.

In the early universe, gas clouds were more homogeneous throughout the cosmos. There were no significant variations in the properties of the gas clouds over large distances or areas. Under the influence of gravity, the gas clouds began to clump and rotate, eventually flattening into disks. As the gas clouds collapsed, they triggered a massive burst of star formation, leading to the creation of the first galaxies.

Over time, galaxies grew and evolved through the process of mergers and accretion. Smaller galaxies merged together to form larger ones, while gas and dust were funnelled into the centre of galaxies, feeding the formation of new stars.

Galaxies come in a variety of shapes and sizes, including spiral, elliptical, and irregular. When two spiral galaxies collide, they lose their spiral arm shape, morphing into the less structured elliptical galaxies. The origins of these different types of galaxies are thought to be related to their different formation histories, including the rate and timing of mergers, the amount of gas available for star

[368] https://www.space.com/supermassive-black-hole-growth-after-big-bang; How did supermassive black holes get so big so fast just after the Big Bang?

formation, and the overall dynamics of the galaxy. Observations indicate that almost every big galaxy has a supermassive black hole at its centre. The black hole at the centre of our Milky Way is called Sagittarius*[369]

Spiral galaxies are thought to form from small preliminary stars and clouds of dust swirling through space. As dust clouds get close to each other, gravity moves these objects swiftly and in an uncontrolled manner against one another. This causes them to grow into larger spinning bodies. Collisions among these objects sling material toward a galaxy's outskirts, creating the spiral arms which are filled with many stars[370].

Galaxies likely started to form 200 million years after the Big Bang, and reached adolescence at around 1 to 2 billion years after the Big Bang[371]. Our planet Earth is in a 13.6 billion year old galaxy called the Milky Way galaxy[372]. This age is somewhat close to the 13.8 billion years age of the Universe. The Milky Way is an enormous, thin, rotating disk consisting of gas, dust, and hundreds of billions of stars. It is enveloped by a halo like a hazy fog, which is thought to be made of dark matter and/or dust and gas. However, with the help of advanced technologies, we now know that galaxies can be much older than we previously thought. In October 2023 and January 2024, an international team of astronomers using NASA's James Webb Space Telescope NIRCam (Near-Infrared Camera) data observed a record-breaking galaxy that formed only 290 million years[373] after the Big Bang. This corresponds to a redshift of about 14.0, or approximately 300 million years at a redshift of 14.3[374].

The Milky Way galaxy is not an isolated galaxy. It is a part of about 50 galaxies called the Local Group. The Local Group itself is part of a larger gathering of galaxies, called the Virgo Supercluster of galaxies[375]. The Milky Way is one of the series of dense regions in the early universe which was formed not long after the Big Bang.

Astronomers suggest that our Milky Way and our nearest neighbour the Andromeda Galaxy are gravitationally bound, and currently approaching each other at a high speed. They are expected to collide in less than five billion years from now, and form a new giant elliptical galaxy[376]. During this collision, it is expected that our Sun and the rest of our Solar System will be ejected from their

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[369] En.wikipedia.org/wiki/supermassive-black-hole
[370] https://svs.gsfc.nasa.gov/11534
[371] https://www.nasa.gov/feature/goddard/2021/back-to-the-beginning-probing-the-first-galaxies-with-webb
[372] https://www.universetoday.com/9828/estimating-the-age-of-the-milky-way/
[373] https://webbtelescope.org/contents/early-highlights/nasas-james-webb-space-telescope-finds-most-distant-known-galaxy
[374] https://webbtelescope.org/contents/media/images/01HZ083EXXCJNE64ERAH2ER2FM
[375] https://space-facts.com/galaxies/milky-way/
[376] https://en.wikipedia.org/wiki/Galaxy_formation_and_evolution

current path around the Milky Way. Mergers between large galaxies are regarded as violent. The frictional interaction of the gas between the two galaxies can cause gravitational shock waves, which can form new stars in the new elliptical galaxy (op.cit.).

In this dynamic universe, the Sun and the Earth are not forever.

Life as we know on Earth is not eternal.

DARK MATTER

Dark matter is a hypothetical form of matter that is believed to exist in the universe. It does not interact with light or any other form of electromagnetic radiation. This makes it invisible to instruments that detect electromagnetic radiation.

Cosmologists have predicted that 23-24% of the total mass in the observable universe is unaccounted for. They claimed the missing mass is dark matter. It is called dark because it does not emit, absorb, or reflect light, hence it cannot be seen directly.

Scientists believe that dark matter should exist because the observed gravitational effects in the Universe cannot be fully explained by the amount of visible matter present. Galaxies, for example, rotate much faster than they should, given the amount of visible matter they contain. This suggests that there must be additional matter present that is exerting a gravitational force on visible matter, but is not visible itself. This additional matter is thought to be dark matter.

The Force of Gravity equation dictates that the further away an object is from the centre of mass the lower the force of gravity, and the slower the object rotates around it. Stars closer to the centre must travel faster than those away from the centre. Otherwise, the stars would fly away from their orbits around the galaxy.

In the late 1970's, an astronomer named Vera Rubin[377], showed that stars in the outer rim of the spiral arm galaxies were moving at about the same velocity as the stars in the inner part of the spiral arm. This violates Newton's law of universal gravitation, which should govern both the motion of stars in galaxies as well as the motion of planets around the sun.

What is holding them back so strongly, while we know the gravitational pull of the galaxy is not sufficient to hold them in their orbits? Similarly, clusters of galaxies appear to be held together by a stronger force than can be accounted for by the gravity of visible matter.

[377] http://arvinash.com/what-is-dark-matter/

These questions led to the introduction of the dark matter hypothesis by Ostriker et al.,[378] who proposed that the rotation curves of spiral galaxies could most plausibly be understood if the spiral galaxy was embedded in a giant spherical halo of invisible dark matter. In other words, there should be a lot more mass on the arms of the galaxies than we can see. A search started but as it turned out, our instruments are blind to it. Whatever was holding the stars in orbit cannot be seen, as it emits no light, no radiation of any sort, and it does not appear to interact in any way with ordinary matter except through gravity.

Ostriker et al's calculation showed that dark matter should have about 5 times more gravity than all the observable and detectable matter in the universe. It looks like a huge portion of the universe is made of dark matter – a new kind of matter that does not interact with regular matter. Note that its existence remains to be experimentally demonstrated. The remaining invisible constituent of the universe was thought to be dark energy, the other mysterious component believed to be the reason for the expansion of our universe. We presented our own views on dark matter later in Chapter XI.

POSSIBLE CANDIDATES FOR MISSING MASS – WIMP AND MACHO

Dark matter is needed to provide the missing mass to hold the fast-spinning galaxies together by providing extra gravity[379]. Dark matter is assumedly the gravitational *glue* which holds galaxies and clusters of galaxies together. The mass typically needed for these particles to account for required amounts should be in the range of 1.0 GeV–1.0 TeV. For example, a non-baryonic WIMP (Weakly Interacting Massive Particles) [380] is one good candidate because its theoretical mass is in the range of 10GeV to 10 TeV [381].

The other major candidate[382] for this missing mass is the baryonic MACHO (Massive Astrophysical compact Halo Objects). There is preliminary, although controversial, evidence for the existence of large numbers of MACHOs[383]. It is likely to be made of some unknown subatomic particles which are expected to interact very weakly with ordinary matter. However, baryonic material probably cannot make up all of the dark matter needed, although it could make up most of the dark matter in

[378] Brian A. Robson (Ed), 2019. Redefining Standard Model Cosmology DOI: 0.5772/intechopen.85605; https://www.intechopen.com/chapters/66783

[379] https://imagine.gsfc.nasa.gov/ask_astro/dark_matter.html

[380] The other dark matter candidates include supersymmetric particles such as neutralinos, photinos, higgsinos, sterile-neutrinos and more.

[381] https://aether.lbl.gov/www/science/wimp.html

[382] The other dark matter candidates include supersymmetric particles such as axions, neutrinos, neutralinos, s-neutrinos, photinos, higgsinos, and more.

[383] http://www.macho.mcmaster.ca/

the halos of spiral galaxies like our Milky Way. Let us note that both WIMPs and MACHOs are theoretical particles; their existence has not yet been proven.

Robinson and Holland (2011)[384] propose that dark matter may be trapped within black holes at the centre of galaxies. They think that dark matter has an increased density, so that it cannot emit light. Galactic centres contain the greatest concentration of mass known in the universe. This is also where we find giant black holes.

At present, dark matter (like dark energy) is one of the greatest mysteries of our science. Detecting dark matter directly is a difficult task as it does not emit or absorb appreciable electromagnetic radiation in any known wavelength[385]. We should probably mention that Lambda Cold Dark Matter is the major theory which assumes the existence of dark matter and dark energy without any direct experimental evidence. For the time being, the mysterious dark matter and dark energy seem to remain as the biggest unsolved scientific problems[386].

Particles gain mass by travelling through the Higgs field. They will slow down as they pass through the field, so that they will travel at a speed slower than the speed of light. Not all fundamental particles have mass. The Higgs field cannot accelerate particles - it does not transfer energy. Massless particles like photons (light particles) will travel through the Higgs field with no impediment as they gain energy, not mass. This is because photons in wave form do not have mass, and in particle form they constantly travel at the speed of light.

It is possible to say that a vacuum is an energy field - the Higgs Field[387]. Experimental evidence for the Higgs field comes from the discovery of the Higgs boson particle. On 4 July 2012, the ATLAS and CMS experiments at CERN announced that they had independently observed a new particle in the mass region of around 125 GeV: a particle consistent with the Higgs boson[388].

If the Higgs field did not exist, particles would not have the mass required to attract one another. They would simply float around freely at the speed of light. Gravity would also not exist, because mass would not be there to attract any other mass.

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[384] Amy Robinson and John Holland, October 10, 2011. Quantum Wave Theory - A Model of Unity in Nature. https://quantumwavetheory.wordpress.com/tag/quarks/

[385] Kim Griest, 2002. WIMPs and MACHOs ENCYCLOPEDIA OF ASTRONOMY AND ASTROPHYSICS. Institute of Physics Publishing 2002 Dirac House, Temple Back, Bristol, BS21 6BE, UK 1

[386] Andrew May, July 16, 2021. Ten wild theories about the universe. https://www.livescience.com/strange-theories-about-the-universe.html

[387] There are other ideas (claims) that suggest that the vacuum space is filled with aether or Dirac Sea, etc.

[388] https://atlas.cern/Discover/Physics/Higgs

How these forces and fundamental particles were formed is beyond the scope of this book. However, particles know how to respond to forces not because they possess brains or follow a coded algorithm, but due to variations in their charge, mass, and spin.

While gravitons are presumed to be massless, they would still carry energy, as does any other quantum particle. Photon energy and gluon energy are also carried by massless particles.

POSSIBLE CANDIDATES FOR MISSING ENERGY – GRAVITON

A graviton is a theoretical particle posited in quantum physics as the carrier of the gravitational force. As a hypothetical quantum entity, the graviton is thought to be responsible for interactions within the long-range gravitational field, much like how photons are associated with electromagnetism and other fundamental forces with their respective particles. While gravitons have yet to be observed or confirmed, their existence is widely anticipated due to the established pattern of all fundamental forces having corresponding mediating particles. The three other known forces of nature are mediated by elementary particles: electromagnetism by the photon, the strong interaction by gluons, and the weak interaction by the W and Z bosons[389].

Gravitons are characterized as massless, electrically neutral particles that are presumed to travel at the speed of light, akin to photons. Although they are generally considered massless, if they were to possess mass, it would likely be very small. This small mass could have significant implications, such as providing insights into dark energy or supporting theories of extra spatial dimensions[390].

The energy of a graviton is defined by its frequency and wavelength, which represent its oscillating motion. Due to the speculative nature of gravitons, their energies and corresponding frequency/wavelength cannot be measured directly at this stage. Instead, scientists utilise mathematical models and experimental methods to infer the properties of gravitons indirectly through the study of gravitational waves. These gravitational waves, which relate to the presence of gravitons, are challenging to detect because of their low energy and extremely long wavelengths (op/cit.).

A good review of the graviton can be found on Wikipedia under the heading “graviton”.

[389] https://en.wikipedia.org/wiki/Graviton

[390] https://www.physicsforums.com/threads/graviton-energy-and-frequency-wavelength.242145/

VI.12. EMERGENCE OF THE SOLAR SYSTEM[391]

Our Sun is a star located in the Orion Arm of the Milky Way galaxy. It is about 26,000 light years from the centre of the galaxy. The Milky Way Galaxy is located within the Local Group, which is a cluster of more than 54 galaxies including our own, our neighbour galaxies the Large and Small Magellanic Clouds, Andromeda, Triangulum, and many others. The Local Group is in the larger Virgo Supercluster which contains about 100 galaxy groups. This Virgo Supercluster is in the centre of about 10 million superclusters which make up the entire observable universe.

According to the nebular hypothesis, the formation and evolution of the Solar System began approximately 4.5 to 4.8 billion years ago[392] with the gravitational collapse of a small part of a giant molecular cloud which was mostly made of hydrogen, in the Milky Way. Most of the collapsing mass collected in the centre which formed the Sun. The rest flattened into a proto-planetary disk out of which the planets, moons, asteroids, and other small Solar System bodies formed[393]. The dense molecular clouds compressed due to gravity, and grew immensely hot and heavy in the centre - becoming the Sun. The matter on the outskirts of this nebula was pushed outward into space due to the force of solar winds. This matter aggregated through gravity and coalesced into proto-planets and potential moons[394].

The Sun is our source of light and heat. Without the Sun, there would be no living organisms on Earth the way we know them. In order for life to start, we needed a place like Earth - a solid ground for plants to grow and animals to roam around.

VI.13. WHAT WE NEED FOR LIFE TO RISE: THE THIRD ROCK, THE EARTH AND ITS MOON

Once the Big Bang set the stage, the universe eventually became home to trillions and trillions of stars, planets, and meteorites whizzing around. In such a dynamic environment at a distance of about 150 million kilometres from the Sun, our planet Earth formed.

According to the Core Accretion model, Earth was formed shortly after the formation of the Sun[395] when gravity pulled hot swirling nebula gases and the planetesimals[396] and formed a ball of

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391 https://en.wikipedia.org/wiki/Abiogenesis

392 https://solarsystem.nasa.gov/solar-system/our-solar-system/in-depth/

393 https://en.wikipedia.org/wiki/Formation_and_evolution_of_the_Solar_System

394 https://www.scienceabc.com/nature/universe/how-was-the-earth-formed.html

395 According to the evidence (see below) from radiometric dating, Earth is about 4.54 billion years old.
- Age of the Earth". U.S. Geological Survey. 1997. Archived from the original on 23 December 2005.
- Dalrymple, G. Brent (2001). "The age of the Earth in the twentieth century: a problem (mostly) solved." Special Publications, Geological Society of London. 190 (1): 205–221. Bibcode : 2001GSLSP.190..205D. doi:10.1144/GSL.SP.2001.190.01.14. S2CID 130092094.

primordial Earth. The accretion phase of the Earth's formation ended approximately 4.5 billion years ago. During this time, an ancient planet in the early Solar System called Theia collided with the early Earth. Some of the shattered debris from this collision gathered to form the Moon[397].

This was followed by a heavy meteorite bombardment period[398]. The heat generated by these collisions made Earth red hot, with top-of-the-atmosphere temperatures upward of 2,000 °C. The high temperatures left only very little geologic evidence available from the original surface of the Earth[399].

The debris coalesced into the planets and started circling the Sun, and one of these spinning semi-consolidated hot balls became the Earth. The heavy bombardment ended about 3.8 billion years ago, and life was likely to be widespread by 3.5 billion years ago[400]. The heavy bombardment also caused repeated evaporation and condensation of Earth's water on various scales. This included the complete evaporation of the ocean, and melting of the Earth's thin crust (op. cit.). The gases released from impacts and chemical transformations created the early atmosphere, which is expected to have been dominated by hydrogen. However, the hydrogen mostly escaped to space, because it was too light of a gas to be retained by Earth's gravity. The loss of hydrogen also meant that less water formed (op. cit.).

After the relative stabilisation of the ocean-atmosphere system, it is currently believed that early Earth's atmosphere may have been dominated by carbon and nitrogen containing compounds[401].

The hot ball of the primordial Earth quickly started to cool down from the outside. This formed the early solidified rocks on which life could flourish. Since then, the composition of the atmosphere has changed several times before reaching its present composition of mainly nitrogen (78%), oxygen (21%,) argon (0.93%),carbon dioxide (0.04%), and trace amounts of neon, helium, methane, krypton, and hydrogen, as well as water vapour[402].

At first, Earth was inhospitable to any living organisms. Several environmental conditions needed to be right for life to start on Earth - a land with breathable air, a non-hostile climate, abundant

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396 Planetesimals are small solid matter that existed during the primordial stage of solar formation. They were crucial building blocks in the formation of planets like Earth.

397 https://en.wikipedia.org/wiki/Theia_(planet)

398 Kurakin, A. The self-organising fractal theory as a universal discovery method: the phenomenon of life. *Theor Biol Med Model* 8, 4 (2011). https://doi.org/10.1186/1742-4682-8-4

399 István Lagzi, Róbert Mészáros, Györgyi Gelybó, and Ádám Leelőssy 2013. Atmospheric Chemistry. Eötvös Loránd University, Hungry. https://ttk.elte.hu/dstore/document/848/book.pdf p.2 *This book is freely available for research and educational purposes. Reproduction in any form is prohibited without written permission of the owner*

400 Kurakin, A. The self-organising fractal theory as a universal discovery method: the phenomenon of life. *Theor Biol Med Model* 8, 4 (2011). https://doi.org/10.1186/1742-4682-8-4

401 Kasting JF: Earth's early atmosphere. Science. 1993, 259: 920-926. 10.1126/science.11536547.

402 https://www.space.com/17683-earth-atmosphere.html

liquid water, energy in terms of food, and plenty of sunshine but without the harmful ultraviolet radiation. Earth met these prerequisites as it was located far enough from the Sun so that it received a moderate quantity of the energy radiating from the sun, but not so far away from the Sun so that temperatures were too cold to sustain life.

Earth is tilted 23.5 degrees from the plane of its orbit around the Sun, so that most of the planet is not always hot or always cold. The ozone layer in Earth's upper atmosphere shields the planet from the Sun's ultraviolet radiation, and the Van Allen magnetic belt stops the destructive solar winds from blowing away Earth's thin atmosphere. The chemical elements like carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus and other trace elements that life strictly depend on are available in sufficient amounts.

It is important to emphasise that Earth became more hospitable when it developed the Van Allen radiation belt[403]. This is a magnetic field which acts like a shield around the Earth. This shield is created from the slowly westward rotation of the charged molten outer core[404,405], which is mainly iron and some nickel. The rotation forms a doughnut shaped magnetic field around the Earth, through convection currents and the Coriolis Effect. The Van Allen radiation belt captures and holds energetic charged cosmic ray particles reaching the planet. This was also a crucial milestone for the creation of a firmer atmosphere, because it shields Earth from solar wind storms.

The ozone layer that envelops the entire planet in Earth's stratosphere, 15 to 30 km above the surface, protects life on earth by filtering UV-B radiation from the sun[406].

Finally, here some interesting facts about Earth and moon:

- According to NASA, Earth rotated faster than usual on June 29, 2022, resulting in 1.59 milliseconds shorter than a standard 24-hour day[407]. I wonder why!
- The Earth moves away from the Sun by 15 cm each year[408], as do all the planets of the Solar System. Could this be the much-needed solution for our climate change problem? Obviously not during my or your lifetime!

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[403] https://en.wikipedia.org/wiki/Van_Allen_radiation_belt

[404] https://www.sciencedaily.com/releases/2013/09/130916162005.htm

[405] Earth's inner core is solid iron and rotates in an eastward direction relative to the mantle. The inner core rotates in the same direction as the Earth but slightly faster.

[406] http://www.eartharchives.org/articles/life-on-land-made-possible-by-ozone-layer/

[407] https://www.verifythis.com/article/news/verify/science-verify/earth-spinning-faster-june-29-2022-shortest-day-in-modern-history-space-fact-check/536-29cc466b-ff7b-4ff8-9e8a-bbc31bd50651

[408] https://www.forbes.com/sites/startswithabang/2019/01/03/earth-is-drifting-away-from-the-sun-and-so-are-all-the-planets/?sh=2e28fe316f7d

- Laser ranging measurements show that the Moon is moving away from Earth by about 3.78 cm per year[409].

- The Moon's existence is essential for Earth. Without the Moon stabilizing our tilt—namely in a no-tilt scenario—there will be no seasons. In a scenario with a large tilt, the weather events will be extreme, including an ice age . Apparently, if the Moon were to disappear suddenly, there would be some disastrous consequences that would have an irreversible effect upon life on Earth[410].

- Tidal movements also help to stabilise Earth's climate. Ocean currents, driven by the tides, distribute warmer water around the globe and influence the global climate. Temperatures could potentially be more extreme on Earth without this influence (op. cit.).

- If the Moon were to disappear, the ocean tides would be much smaller - about one-third the size of what they are now - which means the end of ocean surfing. Animals in coastal environments, such as crabs, mussels, starfish, and snails, rely on the tides for survival.

- If the Moon were not there, the nights would be in absolute darkness. Without any light at night, prey would likely thrive because predators would have a harder time spotting them, which could potentially lead to the extinction of certain predatory animals (op. cit.).

Another study by a team of researchers[411] found that during the last 650 million years, the distance of the Moon from the Earth was approximately 20,000 kilometres farther than it is today, and Earth days were approximately 2.2 hours longer.

VI.14. What We Need For Life to Rise: the Oceans[412]

As the Earth cooled and gases accumulated, water vapour eventually began to condense into thick clouds and the rains began. Precipitation from these clouds filled the troughs and basins which were possibly created by meteorite impacts. This rain continued for millions of years, eventually forming the Earth's first ocean[413].

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[409] https://astronomy.com/magazine/ask-astro/2022/08/ask-astro-how-quickly-is-the-moon-moving-away-from-earth

[410] https://www.rmg.co.uk/stories/topics/what-would-happen-if-moon-disappeared

[411] He Huang et al, Geological evidence reveals a staircase pattern in Earth's rotational deceleration evolution, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2317051121

[412] https://en.wikipedia.org/wiki/Abiogenesis

[413] The oceans of today are the result of much younger movements of continents so-called plate tectonics. The oldest known present day oceanic crust is estimated to be about 200 million years old. This oceanic crust is located in the far western equatorial Pacific, east of the Mariana Island arc. Source: https://www.britannica.com/science/ocean-basin/Evolution-of-the-ocean-basins-through-plate-movements .

Condensation created a thunderous, turbulent atmosphere. It was rich in CO, CH_4, and CO_2, but poor in oxygen. Local volcanic eruptions, lightning strikes and meteorite hits were the sources of energy on this barren, lifeless land.

Oceans may have appeared first in the Hadean Eon, as soon as 200 million years after the Earth formed, in a hot reducing environment. The solution of carbon dioxide in water is thought to have made the seas slightly acidic, giving them a pH of about 5.5[414]. However, the pH rose rapidly towards neutral (~6.8-7.0) when the seawater composition was buffered by reactions involving carbonates and silicates[415].

The 4,404-million-year-old zircon crystals found in metamorphosed quartzite rocks of Mount Narryer in Western Australia provide evidence that oceans and continental crust existed within 150 million years of Earth's formation[416]. This finding was based on the oxygen isotope ratios which showed that this zircon was formed in a granitic magma, and the zircon's interaction with liquid water.

Despite the likely increased volcanism and existence of many smaller tectonic platelets, it has been suggested that when Earth was between 4.4 - 4.3 billion years old, it was covered with water but had little if any continental crust, an extremely turbulent atmosphere, a hydrosphere which was subject to intense ultraviolet light radiation from Sun, and bombarded with meteorite impacts[417].

VI.15. What We Need For Life to Rise: Right Amounts of Sunlight

It would be absolute darkness without sunlight. To start life, we need the right amount of sunlight. Sunlight is important to every single aspect of present and past lives on the planet. Nearly[418] no life could exist without the Sun's light – no plants could grow. The Sun is a source of energy and helps plants to make their own food by the photosynthesis process.

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414 Morse, John (September 1998). "Hadean Ocean Carbonate Geochemistry." Aquatic Geochemistry. 4 (3/4): 301–319. *Bibcode*: *1998MinM...62.1027M*. *doi*:*10.1023/A:1009632230875*. *S2CID 129616933*

415 Morse, John W.; MacKenzie, Fred T. (1998). "Hadean Ocean Carbonate Geochemistry." Aquatic Geochemistry. 4 (3–4): 301–319. Bibcode : 1998MinM...62.1027M. doi:10.1023/A:1009632230875. S2CID 129616933.

416 Wilde, Simon A.; Valley, John W.; Peck, William H.; Graham, Colin M. (11 January 2001). "Evidence from detrital zircons for the existence of continental crust and oceans on the Earth 4.4 Gyr ago" (PDF). Nature. 409 (6817): 175–178. Bibcode :2001Nature. 409..175W. doi:10.1038/35051550. PMID 11196637. S2CID 4319774 . Archived (PDF) from the original on 5 June 2015. Retrieved 3 June 2015.

417 Rosing, Minik T.; Bird, Dennis K.; Sleep, Norman H.; et al. (22 March 2006). "The rise of continents – An essay on the geologic consequences of photosynthesis". Palaeogeography, Palaeoclimatology, Palaeoecology. 232 (2–4): 99–113. Bibcode : 2006PPP...232...99R. doi :10.1016/j.palaeo.2006.01.007. Archived (PDF) from the original on 14 July 2015. Retrieved 8 June 2015.

418 There are tube worms, shrimps, crabs and fish and hundreds more species live in dark deep sea waters near hydrothermal vents where they get their energy in the absence of sunlight.

The Sun is also essential for the existence of every living organism, because without sunlight, all the water and food sources would cease to exist. The Sun regulates the amount of rain falling on Earth. Without the Sun, there would be no clouds, no rain, and no winds. The Sun heats the water in the seas, the lakes and the oceans. This evaporates the water, causing it to rise up as water vapour, which in turn makes clouds. When clouds cool, they condense to become rain and snow. The temperature differences in different parts of the Earth are the cause of winds. Winds move the clouds and spread the rain around.

The Sun emits ultraviolet rays which help in the formation of vitamin D, which is necessary for the growth of bones in vertebrate organisms (if it is not in excessive doses). Sunlight causes mutations which promote diversity, whether beneficial or harmful, to the existing species.

The survival of any living being, whether it is plant or animal, is also dependent on the intensity of the Sun. Life as we know it would not exist if we did not have the thin ozone layer in the stratosphere to filter the destructive sunlight before it reaches Earth. The ozone layer formed in stratosphere around 600 million years ago, and only after the atmosphere was sufficiently oxygenated[419].

Without the Sun's light, the oceans would freeze, temperatures would drop, and all life would cease to exist[420]. Prolonged lack of sunlight was the major cause of the onset of glaciation periods in the geological history of Earth. Any species which cannot adapt to the cold climate perishes. The onset of a glaciation is often related to the dust and gases lifted up following extensive volcanic eruptions and meteorite impacts. Such gases and dust hang in the outer atmosphere and block the sunlight. Too much sunlight is also detrimental for life, as the excessive heat would cause fires and desertification. This would leave many plant and animal species extinct.

VI.16. What We Need For Life to Rise: The Right Atmosphere

The right atmosphere is needed to start life, particularly oxygen breathing life. Early Earth's atmosphere did not contain oxygen. It contained other gases such methane, carbon monoxide, carbon dioxide, sulphur dioxide and hydrogen sulphide. This meant that only anaerobic living beings could[421] exist. Bacteria are the only life forms we know of which depend on these gases as their source of energy to survive.

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[419] http://www.eartharchives.org/articles/life-on-land-made-possible-by-ozone-layer/

[420] https://www.reference.com/science/sun-important-life-earth-b37d026f6d84cc28

[421] Technically viruses also do not require oxygen as they are not living beings.

The atmosphere of Earth played an important role in the evolution of life and in our existence. Approximately 2.4 – 2 billion years ago, Earth's atmosphere and its shallow oceans experienced a rise in oxygen levels [422]. This rise in oxygen content was triggered by the proliferation of cyanobacteria (single cell organisms), which led the way for the eventual development of multicellular organisms[423].

The early atmosphere largely formed from gases released by the constant volcanic activity. It is likely that the volcanic activities were triggered by heat generated by radioactive decay, as well as from extensive meteorite impacts during the period of time 4.1 - 3.8 billion years ago. These poured hot gases from the Earth's mantle to the Earth's surface.

The accumulation of free oxygen is seen as the most significant atmospheric event in Earth's history. Scientific evidence suggests that biologically produced oxygen (O_2) changed Earth's atmosphere from a weakly reducing to an oxidising[424] atmosphere. This caused the pre-existing anaerobic species on Earth to either disappear[425] or adapt to the new environment.

The oxygen producing cyanobacteria played a key role in the emergence of oxygen breathing multicellular organisms, starting from the simplest to the most complex living beings like human beings. Other processes also played a role in the making of a liveable atmosphere:

1. The early ocean waters absorbed a big part of the atmospheric carbon dioxide. At the same time, light from the Sun dissociated the ammonia molecules in the air. This released elemental nitrogen gas (N_2) into the atmosphere. The nitrogen gradually built up in the atmosphere to its present level, but the hydrogen (the other component of ammonia dissociation) largely diffused into space.

2. The Sun's ultraviolet radiation dissociated some of the water vapour and produced oxygen in the atmosphere according to the chemical reaction:

$2H_2O$ + u/v radiation → $2H_2 + O_2$

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[422] Lyons, Timothy W.; Reinhard, Christopher T.; Planavsky, Noah J. (February 2014). "The rise of oxygen in Earth's early ocean and atmosphere." Nature. 506 (7488): 307–315. Bibcode:2014Natur.506..307L. doi:10.1038/nature13068. ISSN 0028-0836. PMID 24553238. S2CID 4443958.

[423] B. E. Schirrmeister, J. M. de Vos, A. Antonelli, H. C. Bagheri. Evolution of multicellularity coincided with increased diversification of cyanobacteria and the Great Oxidation Event. *Proceedings of the National Academy of Sciences*, 2013; DOI: 10.1073/pnas.1209927110.

[424] Sosa Torres, Martha E.; Saucedo-Vázquez, Juan P.; Kroneck, Peter M.H. (2015). "Chapter 1, Section 2: The rise of dioxygen in the atmosphere." In Kroneck, Peter M.H.; Sosa Torres, Martha E. (eds.). Sustaining Life on Planet Earth: Metalloenzymes Mastering Dioxygen and Other Chewy Gases. Metal Ions in Life Sciences volume 15. 15. Springer. pp. 1–12. doi :10.1007/978-3-319-12415-5_1. ISBN 978-3-319-12414-8. PMID 25707464.

[425] Hodgskiss, Malcolm S. W.; Crockford, Peter W.; Peng, Yongbo; Wing, Boswell A.; Horner, Tristan J. (27 August 2019). "A productivity collapse to end Earth's Great Oxidation." PNAS. 116(35): 17207–17212. Bibcode:2019PNAS..11617207H. doi:10.1073/pnas.1900325116. PMC 6717284. PMID 31405980

In the interim, the reaction of carbon dioxide with water catalysed by sunlight (photosynthesis) produced oxygen and organic compounds such as carbohydrates according to the chemical reaction:

$CO_2 + H_2O + \text{sunlight} \rightarrow \underline{\text{organic compounds}} + O_2$

The organic sequestration catalysed by sunlight converted CO_2 from the atmosphere to organic compounds like formaldehyde and oxygen according to the chemical reaction:

$CO_2 + H_2O \rightarrow CH_2O + O_2$

These chemical reactions and other similar reactions removed a considerable amount of CO_2 from the atmosphere to the ocean waters.

3. The CO_2 removal from the ocean waters was also achieved by precipitation of carbonate rocks and minerals like dolomite, limestone and siderite, and to a lesser extent sequestration by vegetation. In the oceans, carbon is stored in the form of dissolved inorganic and organic carbon, and particulate organic carbon (living and dead). Increasingly more CO_2 dissolved in colder waters, hence oceans of colder regions consumed significant amounts of CO_2 to form bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. Calcium, iron and magnesium cations brought to the ocean by rivers reacted with bicarbonate and carbonate anions, to form limestone according to the following chemical equation and also dolomite (Ca-Mg carbonate) and siderite (iron-carbonate) minerals:

$Ca^{2+} + 2HCO_3 \rightarrow CaCO_3\,(s) + CO_2\,(g) + H_2O\,(l)$

The precipitated solids sank to the bottom of the ocean and formed thick layers of carbonate-rich sediments, only to surface later as the mountain chains like the Andes, Alps and Himalayas. The cations (mainly calcium) were also consumed by marine biota to form their shells, bones, and tissues. Although photosynthesis carried out by plants and other organisms remove carbon dioxide from the atmosphere, some of the sequestered CO_2 was released back to the atmosphere via respiration, the decay of vegetation and bushfires.

The organic compounds produced from the action of sunlight on CO_2 and water vapour were the ingredients needed to form early life - the bacteria and single cell organisms which would later evolve into multicellular plants and animals.

In summary, in this chapter we briefly discussed the ingredients needed for life to start. We needed a place like Earth - a solid ground for plants to grow and animals to roam around - water, the essential ingredient to sustain biological life, sunlight and breathable air. No life could exist without

these essentials and we would not have any of the plants, animals to admire. It would be absolute darkness without sunlight.

To start life, we needed the right amount of sunlight – not too little, but not too intense either. Without sunlight, no plant would grow. There would be no rain to fall and no wind to blow. The Sun is every living being's source of energy.

We concluded that a land with sunshine, water and suitable air to breathe, are the essential prerequisites to start the biological evolution from the atoms created by the Big Bang (carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus).

In the next chapter, we will continue discussing other striking aspects of life on Earth. We will point out that life has its own salient characteristics and logical generalities which are largely agreeable with the laws of chemistry, physics, and biology that define the workings of Earth and the universe.

VI.17. PREDICTIONS: HOW WILL THE PRESENT UNIVERSE END?

It is a well-established scientific belief that our universe will eventually cease to exist, whether it may take billions or trillions of Earth years. Scientists have proposed several speculative ideas, models and scenarios about how our universe may come to its end.

Scientific scenarios which talk about the end of the universe differ based on the assumed parameters, but there are basically three prepositions. These are called: Big Crunch ± Big Bounce, Big Rip and Big Freeze[426].

These scenarios differ based on the values assumed for the density and cosmological constant lambda (or assumed geometry) of the universe. The geometry of the universe, whether it has a closed, open or flat shape, is related to its density or how much matter is packed into a given volume of space. There are three possible geometries for the universe: Flat, Spherical and Open:

In a **flat** universe, the interior angles of a triangle (red lines) defined by three beams of light will sum to 180°, so such a space is defined by straight lines. In a universe where the density of matter is the same as the critical density[427], is a flat universe - a space like a sheet of paper. A flat universe

[426] The Beginning to the End of the Universe: The Big Crunch vs. The Big Freeze (31 Jan 2021). In https://astronomy.com/news/magazine/2021/01/the-beginning-to-the-end-of-the-universe-the-big-crunch-vs-the-big-freeze

[427] The *density* by definition is equal to (mass in the region)/(volume of the region). The 'critical density' is the average density of matter required for the Universe to *just* halt its expansion, but only after an infinite time. This requires finding a region of the universe with representative density. If the region is truly representative, then the total mass of the universe = the *density* × the total volume of the universe. A universe with a critical density is said to be flat. If the density is great enough, then the universe is closed. If the density is low enough, then the universe is open. It is customary to express the density as a fraction required for the critical condition with the parameter $\Omega = \rho / \rho_{critical}$ so that $\Omega = 1$ is the critical density of the universe. The critical density ρ_c for the Universe is approximately 10-26 kg/m3 (or 10 hydrogen atoms per cubic metre) and is given by: where H is the Hubble constant and G is Newton's gravitational constant.

has no curvature. If the space is flat and has no curvature, there will be an exact amount of mass to stop the expansion, so its end will be only after an infinite amount of time. A universe which has no bounds will expand forever, but the rate of expansion will gradually approach zero after an infinite amount of time[428].

A **spherical** space is a closed universe, where the interior angles of a triangle would sum to more than 180°. The current values of key parameters suggest that our universe is either flat or slightly open, so that it will expand forever with an accelerating rate. If the universe's density is high enough for its gravity to overcome the force of expansion, then the universe will curl into a ball. This is known as the closed model, with positive curvature resembling a sphere. Such a universe is eventually bound to end by collapsing onto itself.

The saddle-like (or hyperbolic) space represents an **open** universe, in which the angles would sum to less than 180°. In a universe where the density of matter is low, it is an open universe - a horse's saddle-like hyperbolic space. On the other hand, if the universe's density is low and unable to stop the expansion, space will warp in the opposite direction and form an open universe with negative curvature. Such an open universe will keep expanding forever.

In either scenario, whether the universe has a positive curvature resembling a sphere or a negative curvature akin to a saddle, the scale of this curvature would be so vast to us, it would seem effectively flat – a perspective akin to how a beetle perceives the ground as flat when rolling its dung to its nest.

Let us note that the most recent observations of scientists suggest that the shape of the universe is flat. This was verified by the Wilkinson Microwave Anisotropy or WMAP probe. Accordingly, the most agreed upon end for our universe will be a Big Freeze (or Heat Death).

The closed universe ends in a Big Crunch. If the universe is closed, it will eventually stop expanding and converge into a big crunch. This would eventually result in everything ending in a black hole type of singularity[429]. If the expanding universe could not overcome the collective inward pull of gravity, it would end in a big crunch - like the Big Bang played in reverse.

The Big Crunch could be a cyclic event. Every Big Crunch may bounce back, creating a new Big Bang and a new universe each time. Such a scenario is called the Big Bounce.

Source: https://astronomy.swin.edu.au/cosmos/c/Critical+Density

[428] https://www.forbes.com/sites/startswithabang/2021/07/21/why-the-universe-probably-isnt-shaped-like-a-donut/?sh=3b086a986e60

[429] http://arvinash.com/how-the-universe-will-end-and-how-we-can-escape/

According to the Big Crunch hypothesis[430], the expansion of the universe will eventually slow down and halt when it reaches a maximum point of expansion by the gravitational pull. It would then reverse, and all matter would accelerate towards a common centre. The universe would then contract into a hot, dense state.

The version of the Big Crunch model suggested by Nobel Prize winner Roger Penrose (a famous British scientist), says that after the universe has been contracted or collapsed to a certain size, it would explode, and the universe would start expanding again. Each collapse into itself will reach the point of singularity, and each explosion will be the bounce back to a new expanding universe.

This expansion (Big Bang) following a collapse (Big Crunch) model is aptly called the Big Bounce. The bounce marks the end of the previous universe and the beginning of the next. The alternating expansions and contractions of the universe would mean a cyclic universe. If this is the case, the Cyclic Model combines the Big Bang (the birth) and the Big Crunch (the death) models, and hence we live in a universe formed through one of these cycles.

Intuitively, a cyclic universe is an interesting idea considering everything around us is born and dies, and recycles again and again in one form or another. The stars emit light when they are born, and then dim to explode and form a new star. Living organisms are constantly recycled through their babies, by a birth-growth-multiply-die cycle.

Why wouldn't the universe follow a similar cycle of birth, expansion, collapse and then rebound, like many other phenomena?

It is conceivable that the universe has indeed adopted such a process to perpetuate its existence indefinitely, perhaps even expanding slightly after each rebound.

The open universe ends in a Big Rip. If the universe is open[431], it will keep expanding forever and the ultimate fate of the universe is most likely a Big Rip. This is where galaxies would become very far apart, such that we would not be able to see any other galaxies besides our own. The stars would eventually burn out as all the hydrogen gas in the universe is used up.

In time, the matter making the dead cold planets would decay into its atoms, and the protons and neutrons of those atoms would start decaying into fundamental particles and their antiparticles like positrons and electrons. Over time, these would collide and annihilate each other[432].

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[430] https://en.wikipedia.org/wiki/Big_Crunch

[431] http://arvinash.com/how-the-universe-will-end-and-how-we-can-escape/

[432] https://www.physicsoftheuniverse.com/topics_bigbang_bigcrunch.html

The only things remaining would be black holes. And even those black holes would eventually evaporate due to Hawking radiation. This is where a small amount of matter is constantly being discarded and disappearing near the event horizon of black holes.

As time progresses, each radiation, every tiny quantum and energy packet will disperse evenly into the near-absolute-zero expanse, where all movement comes to a standstill and vibrations diminish almost entirely. By 10^{200} years, the universe will have transitioned into a state of emptiness - just a dark void emitting exceedingly faint radiation, just ever so slightly above absolute zero temperature (op. cit.). At this point, the universe would have achieved its utmost entropy state, representing the most stable universal ground state known as the absolute true vacuum state.

The Big Rip model[433] was developed in 2015 by Professor Marcelo Disconzi of Vanderbilt University, in collaboration with physics professors Thomas Kephart and Robert Scherrer[434]. The model claims that the expansion of space accelerates and at some point, becomes so extreme that the force of gravity which holds all objects together - from massive stars, planets and galaxies down to tiny atoms and subatomic particles - will be overpowered. This will rip apart everything in between it - even subatomic particles and the very fabric of spacetime.

The expansion rate of the universe will continue to increase with no limits, as long as the dark energy content of the universe where the negative pressure ratio is less than negative 1.0[435]. As the acceleration continues, gravitationally bound systems such as clusters of galaxies, individual galaxies, and ultimately the Solar System, will be torn apart.

The flat universe ends in a Big Freeze (Heat Death)

The third possibility is that the universe is flat - neither closed nor open. This means it will keep expanding forever,[436] and experience a cold heat death. This is referred to as the Big Freeze[437] but is also called a heat death[438] In cosmology, heat death (or big freeze) refers to a hypothetical death of the universe. This is the state that the universe reaches its maximum entropy and thermodynamic equilibrium so that no more energy or heat can be transferred or used to perform work. In absence of usable energy, the universe becomes a cold and frozen place, hence the term "heat death" is used. There is no bounce back in this scenario - when the universe ends, it ends forever. The Big Freeze

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433 https://en.wikipedia.org/wiki/Big_Rip

434 Marcelo M. Disconzi, Thomas W. Kephart, and Robert J. Scherrer New approach to cosmological bulk viscosity. Phys. Rev. D 91, 043532 – Published 27 February 2015. https://journals.aps.org/prd/abstract/10.1103/PhysRevD.91.043532

435 https://en.wikipedia.org/wiki/Big_Rip

436 http://arvinash.com/how-the-universe-will-end-and-how-we-can-escape/

437 https://en.wikipedia.org/wiki/Heat_Death

438 https://www.physicsoftheuniverse.com/topics_bigbang_bigcrunch.html

will happen when the universe reaches thermodynamic equilibrium (maximum entropy)[439] and according to present scientific knowledge, that is where the expanding universe is heading.

The hypothesis of a universal Big Freeze stems from the 1850's ideas of William Thomson (Lord Kelvin). He extrapolated the classical theory of heat and irreversibility, as embodied in the first two laws of thermodynamics, to the universe. The Big Freeze has been suggested as one of the ways the cosmos could gradually run down to a zero thermodynamic free energy state. This is the state where all energy in the universe is evenly distributed throughout a cold cosmos. The temperature would be just a tiny fraction above absolute zero[440] - a fate similar to the Big Rip.

As the number of gravitating objects, such as galaxies, decreases, the universe's expansion accelerates to a point where it overwhelms the electromagnetic forces holding molecules and atoms together. Consequently, every atomic nucleus would be ripped apart. Even interactions at the Planck scale, the smallest meaningful scale for "space" presently, would cease as spacetime itself unravels, leading to the ultimate end of the universe as we understand it.

The Big Freeze prediction foresees the eventual demise of our universe, marked by a state devoid of vibration, darkness, and coldness, where no genes, molecules, atoms, or subatomic particles exist. This raises the question: what becomes of the energy and matter when they disintegrate and merge into this void of darkness?

[439] https://en.wikipedia.org/wiki/Heat_death_of_the_universe

[440] https://www.physicsoftheuniverse.com/topics_bigbang_bigcrunch.html ; https://bigthink.com/dr-kakus-universe/the-big-freeze

CHAPTER VII: SOME SALIENT FEATURES OF LIFE ON EARTH

VII.1. EVERYTHING WE SEE IN OUR WORLD IS MADE OF VIBRATING ATOMS

Everything you perceive, from your computer and mobile phone to rocks, minerals, water, yourself, your friends, and even your own thoughts and emotions, is either made of or derived from atoms which vibrate continuously, manifesting as energy[441]. This vibration is an intrinsic characteristic of subatomic particles,[442] imprinted upon them during the very early moments of the universe's formation in the Big Bang.

Every atom, every molecule, every matter is made from those vibrating subatomic particles. When molecules made of carbon bonded with hydrogen, nitrogen, oxygen, and other elements in varying proportions, they are termed organic. Essential for life, organic molecules like amino acids, fats, and proteins are crucial components despite being non-living themselves. The objects we observe are entangled, interwoven vibrating molecules. Other molecules create inanimate objects like minerals, rocks, planets, stars, and galaxies, forming our physical world.

Our perception of the world stems from our brain's ability to detect and interpret vibrations sensed through our eyes, ears, skin, tongue, and nose. These vibrations, whether in the form of light, sound, pressure, or chemicals, provide information that our brains process.

For example, heat corresponds to the collective kinetic energy of particles in a system. When a gold coin is heated, its atoms vibrate faster, which is observed as a rise in temperature. Conversely, cooling the coin slows down its atoms, with near absolute zero halting all atomic motion. At such frigid temperatures, substances cannot get colder as their atoms are nearly motionless. Touching an extremely cold coin with warm fingers causes the atoms in your hand to slow down, registering as cold to the brain and prompting the instinct to drop the coin.

Touching a gold coin heated to around 60 degrees Celsius accelerates the atoms in your hand and signals heat to the brain, which then directs the body to release the hot object.

If a gold coin was heated to over 1064 degrees Celsius, the atoms would vibrate so fast that they couldn't hold onto each other anymore and would start to melt. If you continued to heat it even further, to billions or trillions of degrees Celsius, the gold atoms would begin to fall apart. The electrons would separate from the nucleus, and even the nucleus would split apart into quarks. The

[441] Kenneth Wong; https://millennial-grind.com/the-12-laws-of-the-universe-explained/

[442] All together the early stage of the Big Bang created 29 known fundamental particles including three generations of antiquarks, antileptons, neutrinos, and antineutrinos (see Chapter VI.8).

quarks would then break down into gluons, and you would be left with quark gluon plasma[443] - the hottest known state of matter, which existed in the split second after the Big Bang.

If you continued to heat the quark gluon plasma, the particles would continue speeding up, increasing the temperature to about 1.42×10^{32} degrees Kelvin (Planck temperature). Planck temperature can theoretically be reached only during the last stages of the evaporation of a black hole[444].

Our eyes detect vibrating objects and our brains give them shape, size, name and meaning. Light travels as electromagnetic waves. When light reaches the eye, it is converted to photons - the tiniest of particles. When photons bombard the nerves in our body, nerve cells transmit the vibrational energies of the photons to the brain as electrical signals.

Sound is a pressure wave. Our ears detect pressure changes in the form of compression and rarefaction in the air. Our nerve cells transmit these pressure variations to the brain. Our senses are all received and processed in different parts of the brain, either singly or together if they are complementing each other.

A profound fact about our planet Earth is that it teems with life in every corner imaginable - even in the most inhospitable spots. Life is special and unique. One may even tend to think that Earth could be the only place life exists in the entire universe. However, such human-centric thought is statistically unlikely, considering that there are trillions of other planets in the vast universe. Surely, there must be at least a few planets with environmental conditions similar to Earth which meet the prerequisites to start life? As we discussed earlier, there are in fact not too many requirements for life to start. All that is needed is a right distance to their sun, a slightly tilted axis of rotation, a shield against intense sunlight, a hospitable atmosphere, the right climate, and the right amount of land and water. These criteria form a reasonable and not overly ambitious checklist, considering everything on those planets will also be composed of the same atoms of our Periodic Table and governed by the same fundamental forces.

VII.2. All Living Creatures Are Made Of Cells

On Earth, a cell is the smallest living structural and functional unit, and the building block of every living organism. A tiny single cell is amazing machinery, a huge factory. Cells come together and

[443] https://www.quora.com/What-is-the-absolute-zero-temperature-Why-is-it-called-that
[444] https://physics.stackexchange.com/questions/95340/can-plancks-temperature-ever-be-reached

make tissues, organs, organelles, organisms, and every living being - plant or animal, bacteria, fungus, you and me.

A single cell can process its own nutrients, synthesise a variety of molecules for its operation, supply its own energy, and replicate itself. In these terms, a cell is a living entity. And because cells can duplicate themselves, they are potentially immortal - unless some external factors intervene in the operation of this factory.

A cell is usually microscopic in size. The smallest known organism is mycoplasma, a single-cell bacterium. Mycoplasmas are as small as 0.2µm in diameter, whereas a human cell is about 20µm (0.02mm) in diameter[445].

Some organisms, like bacteria or yeast, are nothing more than a single cell whereas human beings are complex multicellular organisms. An adult human body contains around 200 different types of cells[446]. Some examples include somatic cells, like blood cells and muscle cells, and germ cells, like ova (female egg cells) and sperm. The total amount of cells in an adult human body is around 37.2 trillion[447]. This doesn't include the trillions of single cell bacteria which naturally colonise our digestive tract!

Each different type of cell in the human body is adapted to perform a specific function. For example, red blood cells transport oxygen to every part of the body, fat cells store energy, muscle cells enable movement, nerve cells transmit electrical and chemical messages, and sex cells are adapted for reproduction.

Cells are largely composed of water and compounds which contain carbon. The approximate chemical composition of a typical mammalian cell is 70 wt.% water; 18 wt.% proteins; 5.0 wt.% phospholipids and other lipids; 3.0 wt.% miscellaneous small metabolites; 2.0 wt.% polysaccharides; 1.0 wt.% inorganic ions such as sodium, potassium, magnesium, calcium, chloride; 1.1 wt.% RNA and 0.25 wt.% DNA. Aside from water, a cell is composed mostly of macromolecules namely proteins, fats and sugars.

There are 22 different amino acids in a human body which are needed to make different proteins. Nine of the 22 amino acids[448] (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) are essential for the functioning of a body. Essential amino acids

[445] https://www.britannica.com/science/cell-biology/DNA-the-genetic-material

[446] https://biologydictionary.net/how-many-cells-are-in-the-human-body/

[447] *Biology Dictionary*, Biologydictionary.net, 01 Apr. 2021, https://biologydictionary.net/how-many-cells-are-in-the-human-body/

[448] Author apologises for the inevitable use of chemical, biological and medical terms in this book.

are obtained from dietary sources, and methionine, leucine, isoleucine, valine and phenylaniline can be synthesised by the body when necessary. Among the amino acids, selenocysteine is for trace element selenium balance and the regulation of the overall metabolic rate; and pyrrolysine is for methyl transfer to another trace element - cobalt ion.

Amino acids are essential for the body to synthesize proteins, as they are arranged in various combinations, shapes, and sizes, determining the function of each protein. Even a single amino acid change can significantly alter the protein's behaviour. There are around 20,000 genes that encode the blueprints for the same number of proteins[449] in a human body, and 1,000 to 10,000 proteins in a single cell[450].

Life would not be possible without proteins which are made from carbon, hydrogen, oxygen, nitrogen and sulphur. Proteins play essential roles in every living organism. Every antibody, enzyme and chemical messenger is created from protein. Protein is also necessary to provide, maintain and repair anatomical framework and structure, from a cellular level right up to that of the musculoskeletal system.

Proteins act as binding molecules and carrier molecules, allowing for the transport and storage of atoms and molecules throughout the body. They break down larger compounds into waste products, are responsible for the ingredients of reproduction, regulate homeostasis and metabolism, maintain pH values and fluid balance, and provide energy[451].

For example, a family of proteins called cyclophilins play different roles in a cell. Each individual cyclophilin subtype has a unique role, for instance, Cyclophilin D oversees the opening and closing of mitochondrial pores. Cyclophilin E is responsible for regulating mRNA processing[452].

Another role of proteins is to catalyse some biochemical reactions. When acting as a catalyst, a protein needs a surface with unique contours and chemical properties on which a given set of substrates can react. Once an appropriately folded shape is found, the proteins then position metal ions at their active sites[453] to carry out the catalytic process.

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[449] The Protein Puzzle: Cell Research – Biology and Medicine; Max Planck Research 3|17 pp 54-59; WOO3_Biology_Medicine_054-059.pdf

[450] https://www.technologynetworks.com/proteomics/news/how-many-proteins-in-a-cell-study-gives-answer-to-a-fundamental-question

[451] https://biologydictionary.net/proteins-and-nucleic-acids/

[452] Alexander A. Peterson et al, Discovery and molecular basis of subtype-selective cyclophilin inhibitors, *Nature Chemical Biology* (2022). DOI: 10.1038/s41589-022-01116-1

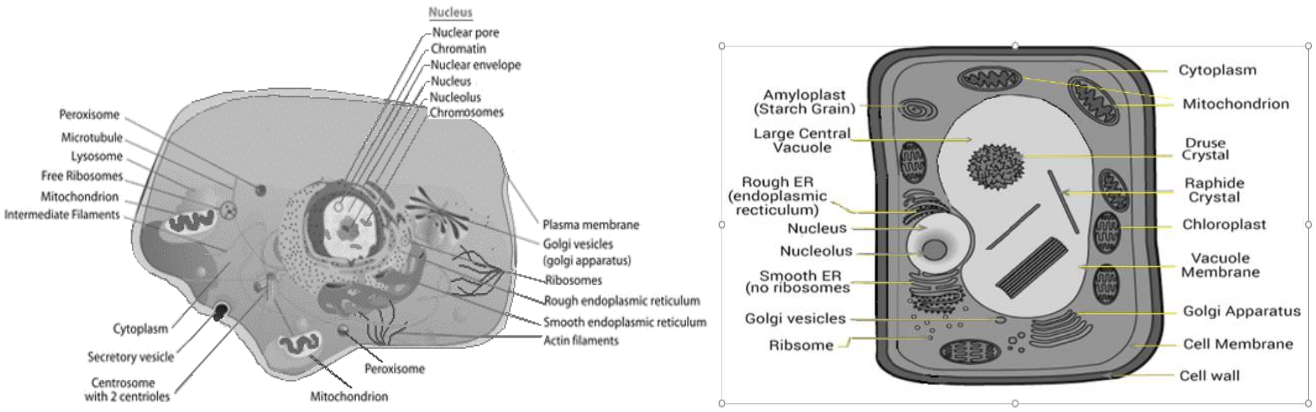
[453] https://www.ncbi.nlm.nih.gov/books/NBK26876/

A cell is an enclosed vessel, within which innumerable chemical reactions take place simultaneously. This makes cells effectively big biochemical factories, where precisely controlled reactions contribute to the life and reproduction of the cell.

The two primary structural cell types are eukaryotic cells and prokaryotic cells. Prokaryotic cells, such as bacteria, lack a membrane-bound nucleus, while eukaryotic cells, including those of animals (including humans) and plant cells, have a true nucleus containing chromosomes. Within eukaryotic cells, the nucleus, housing DNA, is enclosed by a membrane, separating it from other cellular components[454]. In contrast, prokaryotic cells have a single circular strand of DNA and lack a membrane-bound nucleus. Some prokaryotic cells may possess a cell wall, but it is not composed of cellulose unless it is a plant cell[455].

Animal cells contain membrane-bound organelles, including a distinct nucleus. In contrast, bacterial cells do not contain organelles. Membrane is made of phospholipids, which modulates interactions with the other cells and protects the cell.

Animal cells and plant cells share common structural components such as a nucleus, cytoplasm, mitochondria, ribosomes, Golgi apparatus, endoplasmic reticulum, and a cell membrane. However, plant cells have three extra components - a vacuole, chloroplast, and a cell wall[456].



The structural components of an animal (left) and plant cell (right). ER is an abbreviation of endoplasmic reticulum.

The nucleus acts as the cell's "brain", housing its chromosomes (excluding organelle chromosomes) and serving as the site for RNA synthesis and processing in most cells. It stores our genetic information as one of the cell's organelles. Proteins, essential nutrients, are produced by RNA

[454] Bailey, Regina. "The Cell." ThoughtCo, Aug. 26, 2020, thoughtco.com/what-are-cells-373361.

[455] https://www.thoughtco.com/what-are-cells-373361

[456] https://pediaa.com/difference-between-animal-cell-and-human-cell/ and https://www.bbc.co.uk/bitesize/topics/znyycdm/articles/zmrtng8

(ribonucleic acid), a nucleic acid within the cell. Further details about the nucleus will be discussed later in this chapter.

A membrane is composed of a single or double layer of lipid molecules and surrounds all cells. In eukaryotic cells, it also encloses many organelles and can have a double lipid bilayer with associated proteins. The membrane of the human cell is made up of lipids (fats) and proteins. A semipermeable membrane selectively allows specific substances, including macromolecules, small molecules, and ions like Na^{+}, K^{+}, Ca^{++}, to enter the cell.

A human cell is a type of animal cell, with a notable distinction being the size of its genome. While animal cells can vary in genome size depending on the species, human cells have a genome length of approximately 3 billion base pairs. Additionally, the number of protein-coding genes in an animal cell's genome varies by species, whereas the human genome contains around 20 to 25 thousand protein-coding genes[457]. The human body is composed of approximately 200 distinct cell types, each serving specific functions.

All cells in humans and animals that contribute to our makeup are diploid, except for gametes (sex cells, such as eggs and sperm), which are haploid. Haploid cells[458] contain a single set of chromosomes, whereas diploid cells have two sets of chromosomes. Gametes are haploid reproductive cells in sexually reproducing organisms that fuse with one another during fertilisation. This fusion results in a diploid cell that undergoes multiple rounds of cell division eventually forming a new individual. Gametes serve as the physical carriers of genetic information from one generation to the next.[459].

Practically everything in our body, including our brains, heart and entire nervous system, is controlled by electrical signals. Since cells contain the ionic form of atoms such as Na^{++}, K^{+}, and Ca^{++}, the flow of these ions generates electricity[460]. The electrical charge is also transmitted to its destination by flowing from one cell to the next.

The nucleus is the most important part of the cell[461]. Located in the middle of the cell, it contains the cell's entire DNA (deoxyribonucleic acid), chromosomes and genes, which encode genetic material. An important property of DNA is that it can make copies of itself. Each strand of DNA in the double helix can serve as a pattern for duplicating the sequence of bases. This is critical when cells divide,

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457 https://pediaa.com/difference-between-animal-cell-and-human-cell/

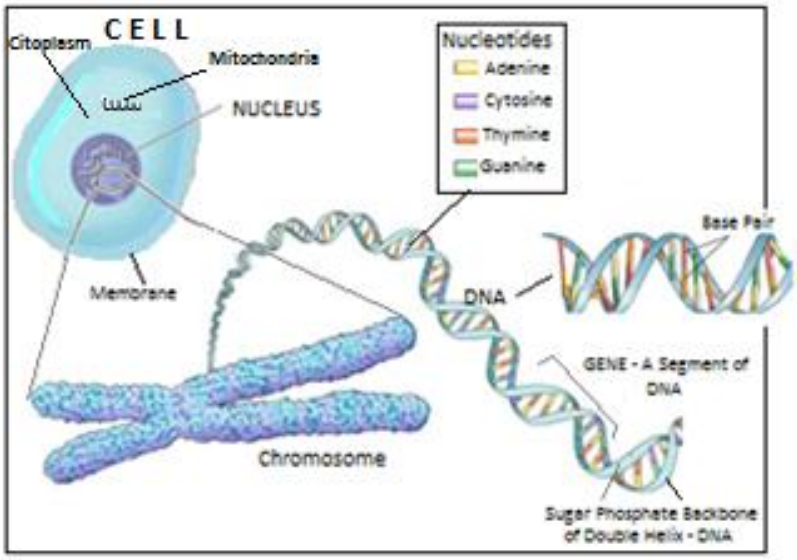
458 Only the egg and sperm cells are haploid.

459 https://biologydictionary.net/gamete/

460 Julia Layton and Mark Mancini, Aug 1, 2022. How Does the Body Make Electricity — and How Does It Use It? https://health.howstuffworks.com/human-body/systems/nervous-system/human-body-make-electricity.htm

461 https://medlineplus.gov/download/genetics/understanding/basics.pdf

because each new cell needs to have an exact copy of the DNA present in the old cell. The nucleus is surrounded by a membrane which protects the DNA and separates the nucleus from the rest of the cell as shown in figure below.



The nucleus is at the centre of the cell and contains chromosomes and DNA, a double helix. Segments of the double helix make genes. Genes are made of base pairs. Modified after: https://my.clevelandclinic.org/health/body/23064-dna-genes--chromosomes

In almost every organism, DNA is the place where all the genetic material is stored. Nearly every cell in a person's body has the same DNA. Information in DNA is stored as codes made up of four chemical bases: adenine (A) $C_5H_5N_5$; guanine (G) $C_5H_5N_5O$; cytosine (C) $C_4H_5N_3O$; and thymine (T) $C_5H_6N_2O_2$. These are simply inanimate organic molecules made up of carbon, hydrogen, oxygen and nitrogen.

Human DNA consists of about 3 billion bases. More than 99% of those bases are the same in all people. The order of these bases determines the information available for building and maintaining an organism, similar to the way in which letters of the alphabet appear in a certain order to form words and sentences.

DNA bases pair up with each other - A with T, and C with G - to form units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar and phosphate are called a nucleotide. Nucleotides are arranged in two long strands which form a spiral called a double helix. The structure of the double helix is somewhat like a ladder, with the base pairs forming the rungs of the ladder, and the sugar and phosphate molecules forming the vertical side pieces of the ladder.

A gene is the basic physical and functional unit of heredity and found as a segment on DNA. Some genes act as instructions to make the vital protein molecules needed for the functioning of the cells. In humans, genes could be made of from a few hundred to more than 2 million DNA bases. An international research effort called the Human Genome Project, which worked to determine the sequence of the human genome and identify the genes it contains, estimates that humans have between 20,000 and 25,000 genes.

Every person has two copies of each gene, one inherited from each parent. Most genes are the same in all people, but a small number of genes (less than 1% of the total) are slightly different between people. Alleles are forms of the same gene, with small differences in their sequence of DNA bases. These small differences contribute to each person's unique physical features.

In the nucleus of each cell, DNA molecules are packaged into thread-like structures called chromosomes. Each chromosome has a constriction point called the centromere, which divides the chromosome into two arm-like sections. The short arm of the chromosome is the p-arm, and the long arm of the chromosome is the q-arm. The location of the centromere on each chromosome gives the chromosome its characteristic shape, and can be used to help describe the location of specific genes. In humans, each cell normally contains 23 pairs of chromosomes, for a total of 46. 22 of these pairs, called autosomes, look the same in both males and females. The 23rd pair differs between males and females, with females having two copies of the X chromosome, and males having one X and one Y chromosome, which are the sex chromosomes[462].

for more information about the components of the cells. In this chapter, inevitably, several medical, biological and chemical terms had to be used. For the description of such technical terms, a proper textbook or internet sites like the link: https://www.ncbi.nlm.nih.gov/books/NBK21052/ should be consulted.

The aim of this section of the book is not to get into details of the components and structural details of the cells. Such information is beyond the scope of this book, but can be found in diverse textbooks like Principles of Anatomy and Physiology[463], The Complete Human Body – The Definitive Visual Guide[464], Encyclopaedia Britannica[465], Wikipedia and scientific journals.

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[462] https://my.clevelandclinic.org/health/body/23064-dna-genes--chromosomes

[463] Gerard J. Torlora and Bryn Derrickson, 2012. Principles of Anatomy and Physiology, 13th Ed. Publisher WILEY.

[464] Alice Roberts, 2010. The Complete Human Body – The Definitive Visual Guide. Publisher Dorling Kindersley Ltd, London.

[465] For detailed discussion of the cell biology *see* https://www.britannica.com/science/cell-biology ; biochemistry of plant cells *see* https://www.britannica.com/plant/plant and https://www.britannica.com/science/photosynthesis . For a full treatment of the genetic events in the cell nucleus, *see* https://www.britannica.com/science/heredity-genetics .

VII.3. EVERY LIVING CELL WORKS LIKE A SOPHISTICATED CHEMICAL FACTORY

As discussed in the previous chapter, the cells of every living being are amazingly sophisticated and act like a complex chemical factory. In fact, there are many factories in a tiny 20-micron cell which each perform different tasks. These factories know how to reproduce themselves, generate their own energy and even dispose of their waste products. Cells perform cellular processes which involve building proteins, breaking down nutrients and converting them to energy, making large molecules from smaller ones, and vice-versa.

Cells know how to make enzymes and speed up chemical reactions. Transcription converts information contained in a strand of DNA into many copies of messenger RNA (mRNA). This is followed by translation, where ribosomes decode the mRNA to construct proteins[466].

The "factory production line" of protein building from amino acids is activated when amino acids receive a code from DNA. This code must be extracted, decoded and transported to ribosomes - cellular protein manufacturing units - by various forms of ribonucleic acid. This is done by the process known as gene expression, which involves transcription and translation.

In the transcription process, DNA code directs the cell to synthesise a specific protein molecule using cellular materials. This process involves 3 stages: initiation, elongation, and termination. The primary goals of initiation and elongation are to generate mRNA. The final step in transcription is termination, marking its conclusion. Guided by a terminator sequence on DNA, the newly formed mRNA detaches itself from the DNA, leaves the nucleus, and enters the cytoplasm, where it binds to transfer RNA (tRNA). Each tRNA carries a single free amino acid. The translation process then begins, converting the genetic code into a protein. Translation results in a lengthy sequence of amino acids known as a polypeptide chain[467], following a specific blueprint initially provided by DNA. A stop codon signifies the end of the translation phase. Only about 1% of DNA is made up of protein-coding genes.

Further information on this amazingly elaborate, strikingly precise multi-step protein making process taking place in a tiny little cell can be found in cell biology books or encyclopaedias like Britannica or Wikipedia, or in a biology dictionary[468].

Another important production line in the cellular factory is the conversion of sugars and carbohydrates to energy. Carbohydrates, in particular glucose, are the main source of energy for nearly all living things. What we eat and drink provides the energy for the cells within us. Glucose

[466] https://news.mit.edu/2018/scientists-find-different-cell-types-contain-same-enzyme-ratios-0329
[467] How Are Proteins Made? https://www.ancestry.com/proteins
[468] https://biologydictionary.net/proteins-and-nucleic-acids/

breaks down during aerobic cellular respiration to form ATP (adenosine triphosphate), which is the form of energy usable by cells[469]. Glucose molecules can be assembled into carbohydrate molecules to store energy for future use. Plants and some other types of organisms produce glucose through the photosynthesis process. Photosynthesis requires an input of energy in the form of light from the sun.

Every cellular factory generates waste products[470]. To avoid any malfunctions, cells have developed a garbage disposal system to keep their home clean. The proteasome is a highly sophisticated enzyme complex which breaks down proteins and peptides by efficient hydrolysis. Proteasomes disassemble damaged, unwanted proteins - the building blocks and mini-machines which make up many parts of the cell. They break them down so that the cell can recycle them when making new proteins.

The 2004 Nobel Prize in chemistry[471] was awarded for discovering the mechanism of this waste disposal process. The researchers[472] found that cells mark their waste with a tiny protein tag known as ubiquitin. When a protein is tagged with ubiquitin, the proteasome can recognise it, capture it, place it inside its structure, break it down, and release the resulting fragments.

Phagocytes, a type of white blood cell within the body, are capable of absorbing bacteria and other small cells and particles. They identify and engulf dead cells and then transfer them to lysosomes, where their cellular components are degraded for recycling.

Cells also engage in the recycling of old and worn-out organelles while removing harmful substances which infiltrate the cell. This vital function is facilitated by lysosomes, which house acidic environments and a variety of digestive enzymes. Lysosomes execute the breakdown of unwanted organelles through autophagy. Furthermore, lysosomes play a pivotal role in addressing viruses, which is crucial for fighting infections within the organism. The inability to produce one of the lysosomal enzymes can result in rare, life-threatening illnesses which may affect multiple organs, including the brain, heart and bones. If lysosomes are unable to digest the cellular waste, the cell may expel it through exocytosis. Once outside the cell, this waste can undergo degradation by other enzymes, undergo disassembly, or be stored as aggregates like plaques, cysts, or lumps.

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[469] https://socratic.org/questions/explain-how-carbohydrates-are-used-by-living-organisms-1

[470] How Cells Take Out the Trash, by Amber Dance (May 15, 2013) https://www.nigms.nih.gov/education/Inside-Life-Science/Pages/how-cells-take-out-the-trash.aspx

[471] https://www.nobelprize.org/prizes/chemistry/2004/summary/

[472] The Nobel Prize in Chemistry 2004 was awarded jointly to Aaron Ciechanover, Avram Hershko and Irwin Rose "for the discovery of ubiquitin-mediated protein degradation"

We must recognise that cells have a limited lifespan – they do not live forever. Even normal cells in our bodies undergo aging and eventual death. As cells age, cellular breakdown occurs. This leads to damage in DNA, genes, proteins, and notably, telomeres and mitochondria within the cells. While cells possess repair mechanisms for such damage, these mechanisms become less effective over time. They are unable to fully reverse the accumulating damage throughout a lifetime, which results in the gradual degradation of our bodies. Each time DNA replicates, a portion of the telomeres, the protective cap at the end of chromosomes, diminishes. Telomeres serve to safeguard useful DNA and track cellular age, but they cannot do this job forever. With each cell division, telomeres shorten until they eventually become too short to adequately protect the chromosomes, leading to cell death[473].

VII.4. How Do Cells Group Together And Make Tissues, Organs, and Organisms?

In a multicellular organism, various cells specialise in distinct functions. To ensure smooth operation, each cell maintains ongoing communication with its neighbouring cells. While receiving nutrients and releasing wastes into its environment, it also adheres to and collaborates with adjacent cells. Similar cells join together cooperatively to form tissues, and the coordination between these tissues gives rise to organs. These organs perform essential functions crucial for sustaining an organism's life and growth. These specialised cells cooperate with others, serving as the fundamental units which construct large multicellular organisms like plants, animals, and humans[474].

What drives cells to organise and construct intricate structures with such precision? The simple answer lies in two key factors: molecular or chemical affinity, and the cells' capacity to transmit and receive information, thereby regulating the behaviour of their signalling molecules[475]. In chemistry, atoms combine to form molecules, and molecules combine further to create more complex substances when there is a chemical attraction or affinity between them. This affinity, influenced by factors such as ionisation energy, ionic size, and charge, aims to produce a stable product with minimal free energy.

At the cellular level, molecule "A" exclusively forms bonds with molecule "D", not with "B" or "C", due to its lack of affinity towards them. The resulting product of this interaction is "AD", which possesses an affinity for another specific chemical. Only when they react together does something

[473] https://www.centreofthecell.org/blog/science-questions/can-cells-live-forever/

[474] https://www.britannica.com/science/cell-biology/DNA-the-genetic-material

[475] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3707615/ Jeremy E. Purvis and Galit Lahav (2013). Encoding and Decoding Cellular Information through Signalling Dynamics. Cell. 2013 Feb 28; 152(5): 945–956. doi: 10.1016/j.cell.2013.02.005 PMID: 23452846 PMCID: PMC3707615 NIHMSID: NIHMS459088

beneficial occur. For a chemical reaction to occur within the cell, the correct molecule must be present. If the molecule is incorrect, there is no chemistry - no "love at first sight," so to speak. Some theories propose that atoms can store information and transmit it to other atoms, a topic we'll explore further in Chapter XII.

Cells communicate with one another, and the information they exchange appears to be encoded within the cell's structural components. Different inputs can be distinguished by changes in concentration, localisation, and modifications over time. These changes encompass static quantities, abundance, identity (like posttranslational modifications or cofactor binding), and the location of signalling molecules. Variations in signal characteristics such as amplitude, frequency, duration, delay, and cumulative level are encoded[476].

When cells proliferate through mitosis (cell division), intercellular chemical reactions prompt them to group together, forming a living, functional tissue. Tissues essentially consist of groups of cells performing similar functions. Cell junctions facilitate cell to cell adhesion and communication. These junctions, comprising multi-protein complexes, enable contact between neighbouring cells or between a cell and the extracellular matrix. This is crucial for coordinated tissue function and overall bodily function[477]. Cell grouping is extremely important – without it our body's integrity would fall apart. It is this organised grouping of cells which gives rise to tissues, organelles, and organs – the fundamental components essential for constructing a functioning body.

Tissue cells from different vertebrate embryos have a remarkable ability to recognise and re-associate with cells from the same tissues. This tissue-specific recognition process in vertebrates primarily relies on a family of Ca^{2+}-dependent cell-cell adhesion proteins known as cadherins. During this process, the cytoplasmic part of cadherin is linked to the cytoskeleton through anchor proteins called catenins[478]. However, as Bruce Alberts et. al. described in 2002[479], cell adherence is more complex than this. Even within a single cell type, multiple molecular mechanisms are involved in adhering to other cells. Some of these mechanisms are associated with specialised cell junctions, while others are not.

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[476] Jeremy E. Purvis and Galit Lahav (2013). Encoding and Decoding Cellular Information through Signalling Dynamics. Cell. 2013 Feb 28; 152(5): 945–956. doi: 10.1016/j.cell.2013.02.005 PMID: 23452846 PMCID: PMC3707615 NIHMSID: NIHMS459088

[477] https://unfocused.me/2017/01/22/how-do-cells-connect-together-in-tissue/ January 22, 2017 by Dustin How Do Cells Actually Connect to Form Tissue?

[478] https://www.ncbi.nlm.nih.gov/books/NBK26937/

[479] Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter (2002) in Molecular Biology of the Cell. 4th edition, New York: Garland Science; ISBN-10: 0-8153-3218-1; ISBN-10: 0-8153-4072-9

Cells are interconnected through various types of cell junctions, each serving specific functions. These junctions include bridge-like structures like Zonula Adherens junctions, rivet-like Desmosome junctions, junctions which clamp adjacent cell membranes together known as Tight junctions), and Gap junctions that connect the cytoplasm of neighbouring cells. See Lumen Learning for further information[480].

Besides proteins, a family of enzymes called phosphoinositide 3-Kinase (PI3Ks) play a significant role in cellular functions like cell growth, proliferation, diversity, motility, survival, and intracellular trafficking.

Tissues come together to fulfill specialised functions. For instance, the functioning of the human lung involves the collaboration of tissues from the bronchi, bronchioles, and alveoli, which work together to facilitate the exchange of oxygen and carbon dioxide with the blood[481].

Tissues combine to form organs, which are the systems of tissues working together on a larger scale to perform specific functions within the body. Some examples of organs include the brain, heart, stomach, liver, kidney, and lungs. Organs can combine to form organ systems.

Organ systems are groups of organs systems that work together to carry out specific bodily functions. Examples of organ systems[482] include the nervous system, endocrine system, cardiovascular system, respiratory system, and digestive system. For instance, the respiratory system involves various organs like the nasal cavities, mouth, throat, lungs, and respiratory muscles, working together to facilitate breathing. The digestive system comprises organs such as the mouth, oesophagus, stomach, small intestines, large intestines, and liver, all contributing to the digestion and absorption of nutrients.

Different organ systems collaborate to form a functioning body. An organism is a distinct, self-contained individual made up of organs. Organisms can be single-celled, like bacteria or amoebae, or multicellular, comprising organs and organ systems. Humans are multicellular organisms and incredibly complex biological entities.

The structure of cells and body parts is much more complex than what is presented here. For more detailed information, consulting a proper textbook[483,484,485] is recommended.

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[480] https://courses.lumenlearning.com/boundless-ap/chapter/cell-junctions/

[481] You can read more on tissues below from the Encyclopaedia Britannica by looking up Organ - biology

[482] https://sciencing.com/five-major-organ-systems-body-8657568.html

[483] A Biology textbook or website should be consulted for more information on these special biologic and chemical terms.

[484] https://unfocused.me/2017/01/22/how-do-cells-connect-together-in-tissue/

[485] You can read more on tissues below from the Encyclopaedia Britannica by looking up Tissue - biology

VII.5. ALL LIVING ORGANISMS NEED ENERGY TO SUSTAIN LIFE

All living organisms require energy for every task they perform. Activities like walking, talking, growing, reproducing, responding to stimuli, and even just staying alive all require energy. The human brain consumes a great deal of energy even during rest, thinking, or sleeping. Similarly, energy is needed for birds to fly, fish to swim, and snakes to slither.

Animals, including humans, get their energy from the food they eat and the water they drink. Nutrients are transformed into energy within cells. This energy is then utilised by various organs such as muscles, nerves, the heart, lungs, and brain, to carry out every bodily function.

HOW DO PLANTS SOURCE THEIR ENERGY?

Plants source their energy in a unique manner compared to animals. They convert light energy from the sun into chemical energy through the photosynthesis process. During photosynthesis, plants take in carbon dioxide and water from the air and soil. Within specialised cells in the leafy part of the plant, water undergoes oxidation (losing electrons) while carbon dioxide is reduced (gaining electrons). This process results in the production of oxygen from water and glucose from carbon dioxide[486].

Plants release the oxygen back into the air and store the energy within glucose molecules. Glucose serves as a simple sugar unit and a source of energy for both plants and animals. Plants utilise glucose to create more complex carbohydrates like starch and cellulose, which are crucial for their survival. These carbohydrates also play a vital role in the food chain, serving as an essential component of animals' diets.

The complex biochemical process in plant leaf cells unfolds as follows:

Within plant cells reside small organelles known as chloroplasts, responsible for storing the energy from sunlight. These chloroplasts contain membrane-bound compartments called thylakoids, which house a light-absorbing pigment called chlorophyll. Chlorophyll absorbs energy primarily from blue and red wavelengths of sunlight while reflecting green light, hence the green appearance of plants. During photosynthesis, chlorophyll converts sunlight into chemical energy using molecules like adenosine triphosphate (ATP) and nicotinamide adenine dinucleotide phosphate (NADPH). The photosynthesis process is light-dependent as it requires a steady stream of sunlight to sustain the reaction.

[486] https://education.nationalgeographic.org/resource/photosynthesis

HOW DO ANIMALS SOURCE THEIR ENERGY?

Animals source their energy from the food they eat, primarily carbohydrates, proteins, and fats. While some animals eat plants, others consume other animals. Within an animal's digestive system, chemicals such as enzymes and bacteria break down the food, converting it into chemical energy. Carbohydrates are broken down into sugars by cells, and the released energy is utilised by cells for various functions. Muscle cells, for example, utilise energy to construct long muscle proteins from small amino acid molecules. Different metabolic processes within animals break down organic molecules, releasing energy essential for growth and survival.

In animals, including humans, ATP plays a crucial role as the primary molecule powering all cellular processes. ATP is a nucleoside triphosphate composed of a nitrogenous base (adenine), a ribose sugar, and three serially bonded phosphate groups. Glucose, obtained from consumed food, is used to produce energy in the form of ATP, along with other high-energy molecules like NADH (nicotinamide adenine dinucleotide) and NADPH. Lipids, or fats, also serve as energy-storing molecules. Lipids release energy when they undergo catabolic reactions.

VII.6. ALL LIVING ORGANISMS REPRODUCE TO CONTINUE THEIR EXISTENCE

Within every living being lies a deep-seated urge to persist, to continue. This urge is encoded within their DNA, driving them to develop mechanisms for multiplication and continuation. It appears that living beings inherently desire to perpetuate their existence and sustain their species. This continuum of existence, or the strong desire to persist, seems to be a universal law applicable to all life forms on Earth.

The urge to survive is reflected in the reproduction instinct of a species. Through reproduction, organisms pass down their genetic material, thus contributing to the continuation of their species. Reproductive instincts vary among different animals, often fuelled by mechanisms unique to each species. Mutual attraction between genders is crucial to this process.

Every living organism possesses an inherent survival instinct and a drive to propagate for continued existence. What fuels this drive? It is essentially a “sugar coating” in biological terms – a reward mechanism encoded into the genes of all living beings by evolution. This reward manifests as extreme pleasure derived from sexual activity, a sensation not exclusive to humans but also observed in mammals and possibly other animals. The experience of pleasure can be observed in brain activity, facial expressions, body movements and muscle relaxation. While scientists have

concluded that animals experience a pleasurable climax, fully understanding another being's emotional state remains elusive[487].

The presence of certain traits in one sex can make them more appealing to the opposite sex. This phenomenon is particularly evident in birds and mammals, where males are often larger, stronger, brighter in colour, or adorned with noticeable features[488]. In the animal kingdom, individuals proficient in attracting mates have higher fitness levels. A stronger male typically has higher success in securing mates, as seen in stags, rams, and bulls using their antlers or horns in contests of strength. Winning males often mate with more females.

This process, known as sexual selection, can lead to increased size and aggressiveness in males (op.cit..). For example, a bull elephant displays heightened aggression during its "musth" period, a time of elevated reproductive hormones. Testosterone levels during musth can be up to 60 times higher than at other times[489]. Researchers[490] suggest that musth is signalled by the release of specific compounds, including pheromones like frontalin and highly odorous chemicals such as ketones and aldehydes. The concentration of these compounds in an elephant's urine and breath indicates its maturity and stage of musth.

A human male and female are drawn to each other by love, a captivating force that encompasses the desire for sexual fulfilment, yet fundamentally serves as Nature's mechanism for ensuring the continuity of the human species. This process is driven by biochemical reactions within the body.

Love can be categorised into three main types: lust, attraction, and attachment. Lust is fuelled by the hormones testosterone and oestrogen, while attraction is orchestrated by dopamine, norepinephrine, and serotonin. Attachment, often associated with reproduction; is mediated by oxytocin, affectionately called the "cuddle hormone". Oxytocin levels surge during intimate activities like sex, breastfeeding, and childbirth[491].

During attraction, high levels of dopamine and norepinephrine flood the system, inducing feelings of excitement, energy, and euphoria. This surge can even lead to decreased appetite and insomnia due to lowered serotonin levels. The hypothalamus in the brain plays a pivotal role in this process, stimulating the production of testosterone and oestrogen from the testes and ovaries. While these hormones are commonly labelled as "male" and "female," respectively, they function in both men

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487 https://www.livescience.com/9631-animals-enjoy-sex.html

488 https://www.britannica.com/science/sexual-selection

489 https://en.wikipedia.org/wiki/Musth

490 The Chemistry Of Sexual Attraction Between Male And Female Elephants. http://www.bio-medicine.org/medicine-news/The-Chemistry-Of-Sexual-Attraction-Between-Male-And-Female-Elephants-6510-1/

491 Katherine Wu, February 14, 2017. https://sitn.hms.harvard.edu/flash/2017/love-actually-science-behind-lust-attraction-companionship/

and women (op. cit.). A more detailed account of Biochemistry of Love can be found in an article published by Carter and Porges (2013)[492].

VII.7. Anything Which Comes to Life is Bound to Die, but Some Seem to Cheat Death

Living organisms are born, grow, and reproduce to ensure the continuity of their species. Eventually, they age and die. But why does death occur?

It is highly likely that the death is not due to a predetermined expiration date coded somewhere within the brain, heart, cells, or any specific part of the body. Instead, death typically results from wear and tear, neglect, misuse, and the genetic instability of the machinery which sustains life.

Death occurs primarily at the cellular level, marking the cessation of metabolic processes rather than the demise of the atoms constituting cells. This phenomenon is governed by the thermodynamic principles, particularly the Second Law of Thermodynamics, which dictates that the entropy of a system increases until reaching equilibrium - the most stable state.

In biological terms, death occurs when a living system reaches maximum entropy, or thermodynamic equilibrium[493]. This state manifests as the cessation of vital functions like the heart, respiration, and brain activity. Living organisms are essentially energy configurations vibrating at specific frequencies. When these vibrations become disordered or "out of tune," the organism loses its harmonious vibration and transitions to a state of equilibrium, akin to returning to its ground state. However, every individual atom within the organism's molecular, tissue, and organ structures persists and continues their vibrational activity.

Living clusters of energy bundles possess an innate desire to survive and maintain their heightened state indefinitely. This drive fuels the creation of new harmonious clusters, akin to our siblings.

Death occurs when the intricate machinery, the coordinated interplay of mind and body, ceases to function. Scientifically, there is no evidence supporting the reincarnation or return to life of a clinically dead individual, either in their previous state or in another realm.

In cases of cardiac arrest, interventions like defibrillation can revive some individuals, but only if the period of declared death does not exceed 3 to 5 minutes[494]. Immediate measures such as CPR (cardiopulmonary resuscitation) are crucial to extending this period and surviving sudden cardiac arrest.

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[492] C Sue Carter and Stephen W Porges, 2013. The biochemistry of love: an oxytocin hypothesis. EUROPEAN MOLECULAR BIOLOGY ORGANIZATION (EMBO) Rep (2013)14/1:12-16; Science & Society Series on Sex and Science. https://doi.org/10.1038/embor.2012.191 https://www.embopress.org/doi/full/10.1038/embor.2012.191

[493] www.biocab.org article Irreversibility and Equilibrium in Biological Systems.

[494] https://www.victorchang.edu.au/cardiacarrest

When something dies, it typically breaks down into atoms, which are then recycled into different shapes or forms, whether living or lifeless. This recycling process may span years, millions, or even billions of years, making it highly improbable for every atom of a disintegrated body to reassemble into its original structure.

Nature, however, has devised an ingenious mechanism to perpetuate genetic continuity by generating offspring from existing living beings. This strategy ensures the survival of species and maintains their existence, driven by the inherent survival instinct encoded in genes. Richard Dawkins, in "The Selfish Gene", attributes this survival instinct to genes, highlighting their central role in every living entity as the genes' home is within cells. We will delve deeper into this concept in Chapter XII.1.

The survival instinct is believed to have been passed down through biological evolution from LUCA, the first living organism from which all others diverged (refer to Chapter IX for more details). This inheritance not only assures the continuity of species but also allows some physical and personality traits to be transmitted to offspring. While Nature does not recreate me from my ashes, it offers a partial chance for my existence to continue through my children. However, my child will not be an exact replica of me because they inherit genes from both me and my spouse. Through my wife and I, our children will also inherit some genes and atoms from our parents, creating a genetic link through generations. For instance, one of our sons looks and behaves like me, while our younger son physically looks more like his grandfather and behaves more like his mother.

As individuals age, the impact of bodily traumas accumulates, leading to increased point mutations and a decline in the efficiency of enzymes encoded by our genes. Mutations in proteins or DNA-synthesising enzymes can result in the production of faulty proteins. If these mutations persist, they can escalate the mutation rate significantly. These factors collectively contribute to the breakdown of cellular machinery and eventual death.

Human beings have always dreamt of everlasting life. Early attempts to combat aging included some spiritual promises, including those offered by the Christian church to the faithful - you will die, but your soul will live forever until Judgement Day - or performing baptisms using elixirs like Holy Water, reminiscent of the mythical Fountain of Youth. This notion of immortality, akin to the Holy Grail Indiana Jones movies, has persisted as a symbol of eternal life through miraculous means.

One prominent scientific theory of aging suggests that our bodies and DNA gradually deteriorate over time until they reach a point where they can no longer sustain life, resulting in death. This theory highlights the concept of wear and tear, the gradual breakdown of cellular materials over the

years, as the underlying cause of our mortality. It is well-supported that cells function less efficiently as time passes, contributing to the aging process. Numerous studies across many different mammalian species provide evidence that exposure to environmental stressors such as dangerous chemicals, ionising radiation, smoke inhalation, excessive alcohol consumption, and illicit drug use accelerates cellular breakdown, leading to many illnesses and ultimately, death.

Cellular breakdown mainly relates to damaged telomeres and mitochondria within cells. In the case of mitochondria, the reduction of oxygen atoms can lead to the generation of reactive oxygen species (ROS) when insufficiently managed. ROS have the potential to oxidise and damage cell membranes, proteins, and nucleic acids, contributing to cellular damage. This damage, particularly to mitochondria, accumulates as the person ages. The mutation rate in mitochondria exceeds that of DNA mutations many times over. Mitochondrial mutations are believed to cause defects in energy production, generate ROS through faulty electron transport, and trigger apoptosis[495] - a form of programmed cell death in multicellular organisms.

These adverse biochemical reactions can lead to cell death through changes such as blabbing[496], cellular shrinkage, nuclear fragmentation, chromatin condensation, DNA fragmentation, and mRNA decay. Age-related declines in mitochondrial function are observed not only in humans but also many animal species[497].

Another prominent scientific theory is the Aging Genes theory, which suggests that genetics are responsible for our ageing and death, given they are also responsible for most of our traits. This is supported by observations in animals, particularly short-lived ones like worms, which seem genetically programmed through their DNA to age and die.

Studies conducted by researchers at Stanford School of Medicine further support the theory, revealing that short-lived organisms such as *C. elegans,* a type of worm, experience death as a part of their genetic programming[498]. The theory gains merit from the fact that *C. elegans* typically live for around two weeks in laboratory conditions, with this short duration of time being insufficient for significant DNA mutations to accumulate. In contrast, humans typically live for around 70 or more years. This provides plenty of time for DNA damage to accrue. However, we don't know the extent to which *C. Elegans* is susceptible to environmental stress. Two weeks lifespan of the species might be sufficient to induce DNA damage.

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[495] http://www.sciforums.com/threads/does-the-law-of-entropy-affect-human-organism-i-need-experts-here.75245/

[496] Blabbing is one of the features of programmed cell death, the cell's cytoskeleton breaks up and causes the membrane to bulge outward. These bulges may separate from the cell, taking a portion of cytoplasm with them, to become known as apoptotic blebs or blabbing. https://en.wikipedia.org/wiki/Bleb_(cell_biology)

[497] https://en.wikipedia.org/wiki/Apoptosis

[498] https://genetics.thetech.org/original_news/news93 or https://asksciencequestions.weebly.com/blog/archives/12-2013

PROGRAMMED CELL DEATH

The scientific name for the process of programmed cell death is apoptosis. Note that this refers specifically to the death of cells, not the body. Apoptosis is used to eliminate unwanted cells -those which have been damaged beyond repair or worn out - to make way for new cells.

The word apoptosis is derived from the Latin verb "to fall off", akin to a leaf falling off a tree. The cell is, in a way, programmed to commit suicide[499]. The process of cell death is a sophisticated one, as it requires many proteins within the cell to be activated and facilitate the disposal of the dead cell.

The absence or uncontrolled occurrence of apoptosis in cells can lead to problems. Without apoptosis, cancer can develop. Too much apoptosis in a healthy individual can result in neurodegenerative diseases such as Parkinson's, Huntington's, Alzheimer's, and Lou Gehrig's disease (op. cit.).

Different tissues use different signals to initiate apoptosis. The protein BMP4 is often used in vertebrates, however the response to BMP4 varies across different tissues. For example, connective tissue differentiates into bone upon exposure to BMP4. A frog's gastrula ectoderm differentiates into skin upon exposure to BMP4. Neural crest cells and tooth primordia respond by initiating DNA degradation and apoptosis[500]. Although blood cells are "programmed" for apoptosis, they can be rescued and kept alive by specific growth factors (op. cit.). A variety of proteins, hormones, and enzymes are involved in this rescue mission. Red blood cell precursors in the liver of a mouse rely on the hormone erythropoietin for survival; otherwise they will undergo apoptosis (op. cit.). These processes occur at molecular and chemical levels.

CAN SOME ANIMALS CHEAT DEATH?

Some animals have incredibly short lifespan, living only a day (such as the mayfly) or a few weeks (like butterflies)[501]. On the other hand, some animals can live much longer than humans; such as the naked mole rat, quaking aspen trees, bristlecone pines, quahog clams, corals, lobsters, and giant tortoises. Remarkably, there are also a few animals that have found a way to cheat death, living indefinitely unless they fall prey to a predator, are caught in a bushfire, or suffer another disaster.

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[499] Apoptosis *December 27, 2022.* https://www.genome.gov/genetics-glossary/apoptosis

[500] https://www.ncbi.nlm.nih.gov/books/NBK10103/

[501] Insects are the shortest living animals on Earth; for example mayfly lives only 24 hours. https://a-z-animals.com/blog/8-shortest-living-animals-in-the-world/

Lobsters can live for over 100 years, but they are not biologically immortal. Their longevity is due to their ability to continuously repair their DNA[502]. Generally, during cell division and DNA replication, the protective end-caps on chromosomes (telomeres) gradually shorten, leading to cellular aging and loss of growth and division capabilities[503]. However, lobsters can produce an enzyme called telomerase, which repairs these lost sections of DNA. This effectively rejuvenates the "aged" cells. Despite this potential for biological immortality, lobsters cannot avoid the exhausting process of regular exoskeleton moulting. This process involves growing a new exoskeleton which demands substantial energy. This leaves the lobster vulnerable to disease and predation over time, eventually leading to death.

Telomerase is not unique to lobsters; in fact it is present in most other animals - including humans. However in most animals, telomerase levels decline after the embryonic stage, rendering them incapable of continuous self-repair.

Another two examples of immortal[504] animals are a species of jellyfish called *turritopsis dohrnii* (*t. dohrnii*) also known as medusa, and a species of hydrozoan known as hydra (*hydra viridissima*). They are both simple animals, and effectively immortal unless they are consumed by a predator, or killed by other means such as a drastic change in their habitat. Both hydra and *t. dohrnii* are from the phylum *Cnidaria*, a diverse group of marine animals. Interestingly, a hydra looks like the polyp stage of *t. dohrnii*.

Hydra is considered immortal because its stem cells have infinite self-renewal ability. This trait appears to be related to the presence of an unusually abundant set of genes known as FoxO (Forkhead box transcription factors of the class O) genes[505]. These genes are found in various animals ranging from worms to humans, and play a role in regulating cell lifespan. Researchers[(op. cit.)] have demonstrated that hydra's cells stop regenerating and die when the function of FoxO genes is inhibited. However, the precise mechanisms of how FoxO genes maintain Hydra's immortality remain unknown, though it is clear that these genes play a crucial role.

T. dohrnii is considered immortal because it can switch back and forth between life stages[506]. The life cycle of this jellyfish begins with a fertilised egg, which develops into a larva. The larva attaches itself to a rock and becomes a polyp, eventually growing into a small colony of polyps. One of these

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[502] 16 Immortal Animals Who Defy Death https://www.bioexplorer.net/immortal-animals.html/

[503] https://www.medicalnewstoday.com/articles/318764#Protective-caps

[504] https://www.science.org.au/curious/earth-environment/animals-can-live-forever

[505] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4783344/

[506] Emma Berthold, Australian Academy of Science https://www.science.org.au/curious/earth-environment/animals-can-live-forever

polyps will form a "bud" or produce separate segments stacked on top of each other, which can break away from the colony. This bud becomes a small jellyfish (medusa) called an ephyra, which then grows into a fully grown adult medusa capable of sexual reproduction (op. cit.).

For most other jellyfish, this stage marks the end of their life cycle, and they die. However, *Turritopsis dohrnii* has developed a unique trick to cheat death. When faced with environmental stress, such as starvation or injury, it can revert to a tiny blob of cells. These cells then transform back into the sexually immature polyp phase. This process is akin to a butterfly turning back into a caterpillar, or a frog becoming a tadpole again (op. cit.).

IS IMMORTALITY POSSIBLE?

Humans have always desired immortality, provided it ensures a good quality of life. In a study by Sangpil Kim et al. (2023)[507], they proposed a method for selectively removing aging cells without harming healthy cells. This innovative approach opens new avenues for treating age-related diseases. The researchers designed organic molecules that target receptors overexpressed in the mitochondrial membranes of aging cells. They developed protein-like nano-assemblies with strong binding affinity to these membranes, causing disruption and subsequent self-destruction of the cells. Their experimental work successfully demonstrated the selective elimination of aging cells by targeting the mitochondria and inducing dysfunction. They argue that their method represents a new paradigm for treating age-related illnesses.

There are now health facilities around the world which offer hyperbaric oxygen therapy. This therapy involves breathing in 100% pure oxygen under high pressure. Doing so encourages oxygen to be quickly absorbed into the bloodstream at a higher rate. Some facilities also carry out blood plasma transfusions, where it is claimed that blood plasma from young healthy people helps with repair, restoration and rejuvenation of old cells. The drug known as Rapamycin, originally used as an antifungal, has been proposed as an anti-aging drug[508]. It is commonly used as an immunosuppressant in clinics, helping to prevent organ rejection during transplant surgery. Rapamycin is also used as an anti-proliferative, which inhibits cell growth, including the growth of malignant or cancerous cells. Rapamycin functions as a blocker, which stops cells from growing and multiplying. This makes it very effective in preventing cancer cells from spreading within the body.

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[507] Sangpil Kim et al, Supramolecular Senolytics via Intracellular Oligomerization of Peptides in Response to Elevated Reactive Oxygen Species Levels in Aging Cells, Journal of the American Chemical Society (2023). DOI: 10.1021/jacs.3c06898. https://phys.org/news/2023-09-aging-cells-possibilities-age-related-diseases.html

[508] Roselle Espina, March 17, 2023. Rapamycin, an anti aging drug: Benefits and risks to health and longevity. https://longevity.technology/lifestyle/rapamycin-an-antiaging-drug-benefits-and-risks-to-health-and-longevity

WILL HUMANS EVER FIGURE OUT HOW TO CHEAT DEATH?

There are some scientific findings suggesting that they might - and sooner than we think.

As the connection between aging, immortality, telomeres, and stem cells became evident, scientists focused on creating drugs to restore telomeres[509]. Their research has revealed that telomeres gradually degrade with each cell division, because DNA polymerases struggle to fully replicate linear chromosome ends.

When telomeres reach a critically short length, cellular senescence (deterioration) is triggered. This prevents DNA double-stranded break repair, leading to chromosomal fusions. To maintain replicative ability, human stem cells express telomerase reverse transcriptase (TERT). This enzyme, along with the non-coding RNA template telomerase RNA component (TERC), forms a functional telomerase ribonucleoprotein (RNP) which adds to telomere repeats, replenishing their length.

There are now a variety of telomere drugs available at pharmacies, although at this stage their effectiveness is unknown. In 2020, a paper published in Stem Cell Journal by Harvard Stem Cell Institute's Dr Suneet Agarwal et al. reported on the development of oral medicines targeting stem cells throughout the body to restore telomeres. They found that oral PAPD5 (an oligo-adenylate) inhibitor restored TERC and telomeres in human hematopoietic stem and progenitor cells (HSPCs). They identified a specific PAPD5 inhibitor known as BCH001, which restored telomerase activity and telomere length in dyskeratosis congenita patient induced pluripotent stem cells. Harvard researchers tested over 100,000 compounds in patient stem cells, expecting that the medicines would increase tissue regenerative capacity in the blood, lungs, and other organs affected by telomeres and other diseases.

For those interested in this topic we recommend Nagpal et al.'s paper below[510]. Please be aware that an unguided use of telomeres drugs available in pharmacies may cause cancer[511].

VII.8. A LIVING THING CAN ONLY COME FROM ANOTHER LIVING THING – AT LEAST FOR THE TIME BEING

One characteristic of life is that a living thing can only come from another living thing of the same species. We are the products of our mothers and fathers, who are themselves the result of many generations of grandparents, and so on. None of us appeared out of nowhere – we are continuations

[509] Nagpal, N. et al. (2020). Small-Molecule PAPD5 Inhibitors Restore Telomerase Activity in Patient Stem Cells. Cell Stem Cell, Volume 26, Issue 6, 4 June 2020, Pages 804-805; https://www.sciencedirect.com/science/article/pii/S1934590920301387

[510] Nagpal, N. et al. (2020). Small-Molecule PAPD5 Inhibitors Restore Telomerase Activity in Patient Stem Cells. Cell Stem Cell, Volume 26, Issue 6, 4 June 2020, Pages 804-805; https://www.sciencedirect.com/science/article/pii/S1934590920301387

[511] https://www.news-medical.net/life-sciences/Telomere-ShorteningAging-and-Cancer.aspx

of previous living beings. Our lineage traces back to a common ancestor, making all Homo sapiens genetically connected. This same continuum applies to every other species, with each sourced from its own common ancestor, and all these common ancestors are linked to the very first ancestor - the LUCA (Last Universal Common Ancestor).

The origin of the very first living being remains a great mystery. We discussed the religious perspective on this creation in Chapter IV. Chapters V to X discuss the scientific explanation as an alternative view. Despite the impressive progress made by scientists worldwide, no living cell or self-reproducing organism has yet been created in the laboratory. Expecting scientists to replicate in 100 or 200 years what Nature developed over millions, if not billions, of years, may be too much, or even unfair.

VII.9. The Afterlife and The Soul – Who Says What?

If there is such a thing as a soul, or a spirit, what happens to it after we die? The soul is defined as an entity and as "the immaterial essence, animating principle, or actuating cause of an individual's life[512]." Soul is thought to be the life force, or vital force, which keeps us alive. It is something that can't be seen, heard, smelt, touched, or tasted. A person of religious faith believes that death comes only after the soul leaves the body. If we could prove the soul exists, a great deal of anxiety over what happens to us when we die would be subdued.

Billions of people believe that the body is mortal, but the "vital force" (an *élan vital*), giving you the conscious mind, remains. This sort of belief is generally held by people of faith, for whom the soul represents the spiritual part of the body, which is separate from the physical part of the body.

In the Hebrew Scriptures, or Tanakh,[513] the early Israelites teach that Adam was created by God from a lump of clay, and the Lord's breath or "nefesh" (or *nephesh*) imparted life into him. Similarly, animals were also given life by the breath of God (Genesis 2:7, 7:22, 6:17; Ecclesiastes 3:19). According to the Hebrew Bible, when we die our nefesh leaves the body and dies. Our breathless body then remains on earth and becomes dust.

In early Judaism, the nefesh is essentially mortal - a living, breathing conscious body, rather than an immortal soul. This concept of the mortal soul was appeared after the Babylonian exile[514], as a result of the Israelites' encounters with Persian and Hellenistic philosophies[515]. The Pharisees

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[512] https://theconversation.com/whatever-the-soul-is-its-existence-cant-be-proved-or-disproved-by-natural-science-61244

[513] Marc Gellman, 2018, When does a soul become a soul? https://www.theadvertiser.com/story/blogs/2018/06/08/when-does-soul-become-soul/681045002/

[514] The Jewish people were forced to leave Judah, Israel and went to live in Babylon between 597 BCE and 538 BCE.

[515] https://en.wikipedia.org/wiki/Soul_in_the_Bible

movement[516] (525 BCE – 70 CE) also played a role. Late Judaism, especially under the influence of the beliefs of Pharisees, eventually accepted the ideas of eternal life, heaven, hell, and the resurrection of the body - ideas which eventually passed to Christianity.

It also appears that later Abrahamic religions were influenced by early Greek philosophers and developed the concept of dualism. In this philosophy, matter represents potentiality, while form represents actuality. Matter is a material substance like clay or red soil, whereas form is an immaterial concept, a pure thought, similar in essence to that of God.

According to Christianity[517], when we die, our spirit and body separate. Even though our body perishes, our spirit - the essence of who we are - lives on and goes to the spirit world. This spirit world is a waiting period until we receive the gift of resurrection, at which point our spirits will reunite with our bodies. Our future resurrected bodies will be immortal and perfect, free from pain and sickness.

The resurrection is made possible by the infinite love of God through Jesus Christ's sacrifice on the cross, ensuring that everyone will be resurrected for judgement. Christians believe in the resurrection of a glorified body, and anticipate a time when God will reunite our souls with our bodies, transforming us into glorified beings: just as Christ was when He emerged from the tomb as the "firstborn from the dead[518]."

The Islamic view of death[519] describes that "when a righteous believer dies, bright-faced angels from heaven descend with divine perfume and shroud. Then the angels of death come, and tell the soul to come out to the pleasure and mercy of God". The soul is then extracted, as easily as water comes out from a pitcher. According to the Qurʿān [520], the Prophet Muhammad (Peace Be Upon Him) describes the soul as spirit, and says "the spirit cometh by command of God" and that "only a little knowledge was communicated to man" (17:85). Humanity was created from "potter's clay, from mud moulded into shape" into which Allāh has "breathed his spirit" (15:28–29). A vital spirit or soul ("nafs") is within each human being.

Hindus, Jains, and Buddhists believe in the reincarnation of the soul. According to Dada Bhagwan[521, 522], the soul is neither born nor dies - it is eternal. For followers of Dada Bhagwan, the soul is a

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[516] The Pharisees were members of a Jewish social movement and their beliefs became the foundational, liturgical, and ritualistic basis for Rabbinic Judaism.

[517] https://www.churchofjesuschrist.org/comeuntochrist/believe/life-has-purpose/what-happens-after-we-die

[518] https://www.ligonier.org/learn/qas/when-person-dies-where-does-his-or-her-spirit-and

[519] https://en.wikipedia.org/wiki/Islamic_view_of_death

[520] https://www.britannica.com/science/death/The-fate-of-the-soul

[521] According to Wikipedia, Dada Bhagwan, is a person, an Indian spiritual leader from Gujarat. He worked as a contractor for a company in Bombay before attaining "self-realisation" in 1958.

permanent entity. When someone dies, their soul departs and spontaneously enters another embryo in a new womb. Thus, after death, the soul acquires a new body. This new body could belong to an animal if the deceased individual led a devious or dreadful life.

The departure of the soul from the body has always been central to the Christian understanding of death. In Christian teachings, death is a significant event where the soul immediately goes to be with God and continues to exist[523]. The faithful believe that life does not end with physical death; instead, we remain alive through our personal souls.

The term "vital force" dates back to the Middle Ages (5th to 15th centuries) and is associated with the theory of vitalism. According to this theory, human beings are endowed by God with a special, magical property - the soul - which makes them living, breathing beings. This vital force (soul or spirit) within living organisms is considered the essence of life. People were taught to believe that the soul is immortal, and that it leaves the body upon death and goes to either heaven or hell, or remains in a state of limbo until the day of resurrection.

Humans tend to easily believe in superstitious ideas. Conveniently, we can create stories because of our fear of death, the great unknown - oblivion. We desire to control our afterlives, just as we have controlled our daily lives. The question of what happens to us when we die both intrigues and scares the human mind.

Religions offer comfort and reassurance to those with insecure minds by promising that the soul - the essence of one's being - is immortal. They teach that Jesus will save and resurrect the soul of anyone who believes in Him, granting believers a place in heaven. Many people embrace religion to find meaning in the mystery of death and to cope with the uncertainty of the afterlife[524].

There have been various attempts to prove the existence of the soul. One of the most famous is the "21 grams experiment"[525] conducted in 1907 by Duncan MacDougall, a physician from Haverhill, Massachusetts. MacDougall hypothesised that the soul has physical weight, and attempted to measure the mass lost by a human body at the moment of death. He measured the weight change in six patients, and reported that one of them lost 21.3 grams at death. This experiment is widely regarded as flawed and unscientific due to the small sample size, the methods used, and selective reporting - only one of the six subjects showed the hypothesised result. The experiment was an

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[522] https://www.dadabhagwan.org/path-to-happiness/spiritual-science/science-of-death/when-soul-leaves-body/

[523] https://www.ligonier.org/learn/qas/when-person-dies-where-does-his-or-her-spirit-go

[524] Lewis Wolpert, *29TH JANUARY 2018.* How the fear of death gave birth to religion; https://newhumanist.org.uk/articles/5282/how-the-fear-of-death-gave-birth-to-religion . *a preview from the* Winter 2017 edition *of New Humanist.* New Humanist Mind, Body & Life

[525] https://en.wikipedia.org/wiki/21_grams_experiment

unfounded attempt to measure something invisible, like energy, as if it were a physical substance with mass.

MacDougall did not have any more experimental breakthroughs considered remarkable enough to report in regards to measuring the human soul after 1907. He passed away in 1920[526]. Nonetheless, the 21 grams experiment made his name immortal in history, even though it was not very commendable[527]. MacDougall's efforts to prove the existence of the soul through physical means were labelled as a little more than a fool's errand, akin to an attempt to prove that the number 2 is twice as big as the number 1 by simply weighing it (op. cit.).

Other attempts to prove that the soul exists were made in the early 19th century. W.J. Kilner and independently Dr. Patrick S. O'Donnell captured pictures of the aura around the body on a X-ray sensitised screen of glass. These experiments were less publicised and so not much is known about their results. Seeking physical evidence to prove the existence of the soul flies in the face of a great deal of philosophical and theological scholarship[528]. The soul remains elusive - whatever it may be cannot be proved or disproved by natural science (op. cit.).

Before the early 1900s, most people believed what clergymen had said to them – that living things were endowed with a soul which made them living, breathing organisms (vitalism). According to vitalism, all living organisms contained a vital force that was the very essence of life. In their view, an object was inanimate because it did not have the vital force - the enabling factor which is present in all living things[529].

During early days, it was also believed that urea was a chemical of life as it can only be produced from the kidneys of a man or a dog. This belief was challenged when Friedrich Wöhler, a German chemist, made urea artificially by treating silver cyanate with ammonium chloride[530]. For the first time, an organic compound was artificially synthesised from inorganic materials, without the involvement of living organisms (op. cit.). Although the results of Wöhler's experiment completely discredited vitalism, vitalists claimed that urea could not be made if it was not filled with the life energy of the humans. Thus, they declared that Wöhler's finding was still compatible with the theory of vitalism.

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526 https://www.snopes.com/fact-check/weight-of-the-soul/

527 PUBLISHED: JUNE 29, 2016. HTTPS://THECONVERSATION.COM/WHATEVER-THE-SOUL-IS-ITS-EXISTENCE-CANT-BE-PROVED-OR-DISPROVED-BY-NATURAL-SCIENCE-61244

528 https://aleteia.org/2019/07/18/researchers-attempt-to-prove-the-presence-of-the-soul-scientifically/

529 https://science.fandom.com/wiki/Vital_Force_theory

530 https://en.wikipedia.org/wiki/Urea#History ; $AgNCO + NH_4Cl \rightarrow (NH_2)_2CO + AgCl$

Other scientists followed Wöhler's footsteps, and soon it became clear that the chemicals of life could all be made from other chemicals that have nothing to do with life. Although this was the end of vitalism as a scientific concept, it was extremely hard for some to let go of the idea because it contradicted the Bible. Thus, the concept persisted for quite some time. Even scientists have struggled to shed vitalism: as late as 1913, Benjamin Moore, an English biochemist, was passionately attempting to revitalise the theory of vitalism under another name - "biotic energy"[531]. Even today, there are still many people emotionally attached to the core concept of vitalism - the existence of the soul.

Contrary to religious teachings and ancient beliefs, those who know about the scientific method say that when you die, you die. Death is a fundamental feature of life: we are born, we live, and we die. We know this indirectly, for example from old Egyptian tombs of pharaohs. Old Egyptian kings, queens and nobles believed in the afterlife. They stored food and valuables next to their mummified corpses for their next life. These items were found untouched thousands of years later, by archaeologists or tomb-raiding thieves.

Traditional thinking (dualism) claims that living entities differ from inanimate ones, because they contain a non-physical element such as a soul. Tegmark argues against dualism by saying[532]: *"Support for dualism among scientists has gradually dwindled with the realisation that we are made of quarks and electrons, which move according to simple physical laws. If your particles really move according to the laws of physics, then your purported soul is having no effect on your particles, so your conscious mind and its ability to control your movements would have nothing to do with a soul".*

Modern science says that memory, consciousness, thinking, and feelings, are all the results of biochemical activities which can be explained without any divine intervention. The scientific view says that the *"soul is the sum total of your neuro-cognitive essence, your very specific brain signature"*, and *"the unique neuronal connections, synapses, and flow of neurotransmitters that makes you alive and the person you are"*[533].

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[531] Michael Marshall 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

[532] "Consciousness as a State of Matter" written by Max Tegmark Consciousness and Physics 1401.1219.pdf arXiv:1401.1219v3 [quant-ph] 18 Mar 2015

[533] Marcelo Gleiser, Is Neuroscience Rediscovering The Soul? April 5, 2017. https://www.npr.org/sections/13.7/2017/04/05/522738015/is-neuroscience-rediscovering-the-soul

VII.10. The Brain is the Command Centre, but Not the Home for the Soul

If there is a soul which exists independent of the body, then assuming it is a material thing, should it reside somewhere in the body? If the soul is related to life and death, then it should be able to enter and leave the body.

How and When the Soul Enters and Leaves the Body

How the soul enters and leaves the body is a big dilemma (assuming the soul does in fact exist). There is no scientific proof of the soul entering and leaving the body. The existing explanations are all religious-based. In any event, how and when is a soul allocated to a newborn baby?

Hindus believe that the human soul is naturally and essentially immortal - that it is uncreated and eternal. The soul passes from one body to another through a series of many incarnations. After paying off its karmic debt, the soul is liberated from somatic existence and lives in a totally blissful state[534].

On the other hand, according to the Bible's Old Testament (Genesis 2:7), God did not make a body and put a soul into it. Rather, He formed man's body from dust, and then made the body of dust come to life by breathing divine breath into it. The dust did not embody a soul, but it became a soul - a whole creature[535].

The question of when the soul enters the body is disputed among many religious scholars. The dominant theory is that the soul enters the body at conception. However, others teach that the soul does not enter the fetus until 40 days after conception. All Jewish, Christian and Muslim teachings affirm that the fetus has a soul long before birth.

There is also an unresolved debate about reincarnation of the soul, and its recycling. In the concept of reincarnation, souls of dead people are inserted into foetuses, and they live again. Another belief is that each soul goes through life only once, and that the soul returns to God to be absorbed by God or to live with God, when the body dies.

If souls do reincarnate, then why can't people remember their previous life? Hinduism answers this question cleverly: so the baby is not burdened or bewildered by knowledge of its previous life. There is a legend which says that just before birth, an angel taps the baby on the upper lip and leaves an indentation which causes the child to forget his or her previous life.

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[534] https://www.webpages.uidaho.edu/ngier/103/soul.htm

[535] https://en.wikipedia.org/wiki/Soul_in_the_Bible

LOCATION OF THE SOUL – IS IT IN THE HEART OR THE BRAIN?

The location of the soul is also unknown. The search for the location of the human soul likely dates back to the first awareness of such an entity. The early Greeks and Romans considered that the soul resides within the body, but is distinct from the human body. Ancient anatomists and philosophers all believed in the existence of the soul. They claimed that the soul should be located in either the lungs, heart, or brain - the organs which are vital for life.

Thomas Willis (1621-1675), a Professor of Natural Philosophy at Oxford University, conceived of *"a middle part of the brain, a kind of interior chamber of the soul… in the innermost part of which images or representations of all sensible things, sent in through the passages of the nerves… are revealed upon the corpus callosum… and so induce perception…"*[536].

Albrecht von Haller (1708–1777) placed the soul in the medulla oblongata, the connection between the brainstem and the spinal cord[537].

In the very early days, Pythagoras (c. 570 – c. 495 BC) thought that the soul consisted of three parts: intelligence, reason, and passion. The seat of the soul extended from the heart to the brain, passion being in the heart, and reason and intelligence being in the brain[538]. Leonardo da Vinci (1452–1519), placed the soul above the optic chiasm in the anterior-inferior third ventricle of the brain[539].

René Descartes (1596–1650) distinguished between the body and the soul, but equated the mind with the soul. He localised the soul in the pineal gland of the brain,[540] as it lay deep within the midline of the brain, and was unpaired.

Lancisi (1654–1720) also thought that the soul must lie deep within the midline of the brain and in an unpaired structure, but favoured the corpus callosum as the soul's location: particularly the medial longitudinal striae of the corpus callosum. He felt that vital spirits could flow in the fibres of the medial striae. These formed a pathway for the stream of the soul (or perhaps the stream of consciousness), between the anterior part of the corpus callosum, the anterior columns of the

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536 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3115284/

537 Trimble M.R. The soul in the brain. The cerebral basis of language, art and belief. Baltimore: The Johns Hopkins University Press; 2007.

538 Prioreschi P. *A history of Greek* Medicine. Vol 2. Omaha: Horatius Press; 1996.

539 Santoro G, Wood M.D, Merlo L, Anastasi G.P, Tomasello, Francesco G. A. The Anatomic Location of the Soul From the Heart, Through the Brain, To the Whole Body, and Beyond: A Journey Through Western History, Science, and Philosophy. *Neurosurgery*. 2009;65: p633–643.

540 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3115284/

fornix, and the posterior part of the corpus callosum and the thalami - a connection between the seat of the soul and the peripheral organs, between the soul and the body[541].

Those locating the soul to the heart, point to the fact that you die when your heart stops beating. This is interpreted as the soul leaving the body. We know that the chambers of the heart stop contracting when you die. This makes blood pressure fall sharply, and stops the blood pumping into circulation.

Scientifically, we now know that stopping the heart triggers a cascade of effects all over the body. The worst of these effects is the stoppage of oxygen into brain cells, which is needed most for keeping a person conscious. An unconscious person becomes unresponsive, and his or her breathing and pulse both stop. Such a person looks dead, and the soul should have left the body. However, cells in other parts of the body such as the brain, are still alive - some form of metabolism continues for another several minutes. The heart muscle cells start deteriorating, but if the heart is reactivated at an early stage by massaging the chest, or by CPR (cardio-pulmonary resuscitation) and/or the use of a defibrillator, the heart starts pumping again and the brain cells are supplied with oxygen. The person then regains consciousness and "comes back to life"[542].

A dead person can be revived with a defibrillator or CPR only before the death spreads into every cell of the body, especially to the brain. Because the required intervention time is so crucial, scientists have developed pacemakers. These are effectively implantable defibrillators, which can perform this intervention instantly when inserted into the chest. The possibility to "jump-start" a stopped heart is interpreted as though the heart may not in fact be the place to host the soul.

Most people now think that the brain is the most likely place for the soul to reside. This is because the traits of being alive, such as the mind, thoughts, and consciousness, are all located in the brain.

In 2009, Santoro et al.[543] reviewed literature regarding the nature and location of the soul in the human body. They found two dominant concepts of the soul: one that sees the soul to be spiritual and immortal, and the other that conceives the soul to be material and mortal. In both cases, the soul has been in a specific organ or anatomic structure, as pervading the entire body, and in some instances, beyond mankind and even beyond the cosmos.

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[541] Di Ieva A, Tschabitscher M, y Baena R. R. Lancisi's Nerves and the seat of the soul. *Neurosurgery*. 2007; 60:p 563–568. doi: 10.1227/01.NEU.0000249283.46514.93.

[542] Antoine van Gelder, https://www.quora.com/Can-someone-dead-be-revived-with-a-defibrillator-Im-writing-a-book-and-I-want-it-to-be-as-accurate-as-possible

[543] Santoro G, Wood M.D, Merlo L, Anastasi G.P, Tomasello, Francesco G. A. The Anatomic Location of the Soul From the Heart, Through the Brain, To the Whole Body, and Beyond: A Journey Through Western History, Science, and Philosophy. *Neurosurgery*. 2009; 65:p633–643.

Some neuroscientists have speculated about the location of the soul. Neurosurgeons who perform delicate operations within the brainstem are known to tell their postgraduate students: *"We are now in the abode of the soul"*[544]. These comments suggest that the soul might reside in the brainstem[545] or within the deeper regions of the cerebrum and brainstem[546].

When the brain is partially or completely damaged as the result of sickness or accident, it affects the behaviour, cognitive, emotive and other functions of the person. One widely publicised example of this is what happened to Mr Phineas Gage, an American railway worker, in 1848[547]. In an unfortunate workplace accident, a metal rod pierced Mr Gage's left cheekbone and the frontal lobe of his brain. The rod came out from the top of his skull, and he survived. However the accident changed his personality: Mr Gage went from being a pleasant, extremely nice person to become an irritating, vulgar, uncontrollable, irresponsible, profane, and abusive alcoholic (op. cit.).

Some are not convinced about the existence of souls, and see no reason to believe in souls residing in the human brain. They have said: *"Because we are yet unable to understand it, we call it immortal. It is the ignorant, lazy man's refuge"*[548].

In 2002, Otto Rank said that *"belief in the soul grew out of the need to reassure ourselves of immortality, despite our knowledge of the immutable biological fact of death: The immortal soul, whether fact or fiction, gives comfort"*[549]. This is akin to the placebo effect.

V. S. Ramachandran, a brain scientist at the University of California, San Diego, says that *"an immaterial spirit that occupies individual brains and that only evolved in humans - all that is complete nonsense",* and that belief in the soul *"is basically superstition"* (op. cit.).

The foregoing discussions demonstrate that there is no basis to assign the brain or heart as the home for the soul, because their functioning simply depends on the supply of blood and oxygen, and the workings of cells.

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544 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3115284/

545 Christopher Pallis, 1983. ABC of Brain Stem Death. London, BMJ, Volume 70, Issue 9.

546 Greenfield, Susan, 1997. The Human Brain: A Guided Tour. London: Weidenfield and Nicolson, 1997. Pp. 162, ISBN 0-297-81692-6.

547 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3115284/

548 Marshall E. 'No Immortality Of The Soul' Says Thomas A. Edison; In fact, he doesn't believe there is a soul - human beings are only an aggregate of cells and the brain only a wonderful machine, says wizard of electricity. *The New York Times Magazine*. 1910 2 October.

549 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3115284/

VII.11. EVERYTHING DECOMPOSES INTO ATOMS, WHICH ARE RECYCLED TO FORM NEW THINGS

Another intelligence that the universe put in place is its recycling mechanisms. When we look around, we see that everything - living and nonliving - is continually recycled from one form to another. This is how the present universe, or what we call Nature, operates. Stars are born from gas and dust clouds, glow until they burn their nuclear fuel, and then collapse in an exploding supernova. A new star is then formed from the fragments, gas and dust clouds of this explosion. Although the new star is not a carbon copy of the original star in size, shape, or composition, most of its constituents are recycled atoms from the previous star, possibly evolved into different proportions due to the addition of new, heavier elements. The intelligence behind this recycling process ensures that overall energy balance is kept to a minimum, at or near zero, so that everything is created from something else.

We observe the recycling of inanimate objects on Earth. Take Española Island in the Galapagos as an example. Millions of years ago, this island rose from the bottom of the ocean, forming a mighty tall crater from layers of erupting lava. It became covered with a canopy of plants and a variety of animals. Meanwhile, erosion began breaking down the solid rocks into boulders, then into gravel and sand, eventually reducing the island to a small, flat landmass that will soon disappear completely beneath the sea. The once-mighty volcanic crater that ended up as sand and gravel on the ocean floor will one day melt again when the shifting oceanic plates push it under a continent, transforming it into molten magma that will erupt again elsewhere. This process explains how the world's biggest mountain chains, such as the Himalayas, Andes and Alps, as well as islands like Hawaii and the Galapagos, which are now rapidly eroding, were formed.

Recycling of the living and non-living inhabitants of the universe are carried out by physical and chemical processes such as decomposition, degradation, decay, and reconstitution. Meteorites and comets can cause degradation through their wind, chemical erosion and impact. Eventually, all non-living matter, whether it is a star, sun, planet, or rock, disintegrates into its components and atoms through nuclear, chemical, or physical processes.

The cyclic model of Penrose suggests that the present universe will eventually disintegrate into atoms, and then into subatomic particles, only to snap back and to trigger a new Big Bang, starting the entire process again.

Living beings are constantly being recycled. We, like every other living being, are born small, grow bigger, and then die; decomposing into atoms that once made the flesh and bones of a living body. Upon your death, these atoms may end up in a cow's milk, to be consumed by a young fertile man or woman, and end up in a newborn baby. Or they could end up being sand at the bottom of the ocean,

or be the shell of a mollusc, bones of a fish in a river, or blown by the wind to an orchard or veggie patch, to take part in another episode of Nature's marvels.

The atoms and elementary particles which make our bodies are recycled over and over again in one way or another. Many of the atoms we are made from, the iron in our blood and the calcium in our bones were sourced from a star which exploded billions of years ago. Hydrogen atoms make up 10%[550] of the human body, and almost all of these hydrogen atoms were formed at the point of the universe's creation 13.7 billion years ago – long before the Earth's consolidation into its present shape.

In summary, every object in the universe constantly recreates themselves from the relics of previous events.

VII.12. Food is Recycled Within a Food-Chain (Pecking Order) System

The food cycling system is another efficient recycling mechanism on Earth. In this system, most, if not all, living organisms depend on each other's existence, ensuring that nothing is wasted. Organisms are interconnected through the food they eat. There are food-producing organisms like grass or fruit trees that utilise radiation from the Sun and nutrients from the soil to grow, while others consume these plants, leaves and fruits, serving as food for yet another organism. The conversion of sunlight into food and the creation of a sophisticated food chain is the basis of existence of all living beings.

In the food cycling system - the pecking order - a big fish eats a smaller fish and so on is the underlying principle. This hierarchy system of Nature is unique and a highly efficient way of sustaining the continuity of species. Every living organism's existence is intertwined with that of another organism. The food chain is like a pyramid or chart which illustrates how food is produced, consumed, and recycled among living beings. The pecking order describes who eats whom in the wild, which is important for the survival of most species. If the chain is broken and an alternative is not quickly established, it can lead to the extinction of one or more species[551].

At the bottom of the food chain pyramid lies the producer organisms, like grass and trees. They convert sunlight into energy via photosynthesis. On top of the food chain are the predator species, like polar bears and orca whales. In between them lie the detritivores, like earthworms and woodlice, and the decomposer species such as fungi and bacteria. In the food chain, humans are consumers because our existence depends on other organisms, plants, and animals. This

[550] https://www.news-medical.net/life-sciences/what-chemical-elements-are-found-in-the-human-body.asp

[551] https://en.wikipedia.org/wiki/Food_chain ; https://education.nationalgeographic.org/resource/food-chain

theoretically locates us right in the middle of the food chain, between pigs and anchovies[552]. However, humans are capable of producing their own food. We humans have mastered agriculture, husbandry, poultry and the production of food crops, fruit, and every edible food on a large-scale. We can ship our produce anywhere in the world.

Humans are also predators to many wildlife species which sit at the very top of the food chain. We have the capability to defeat the most vicious of carnivores like bears, orca whales, lions, and tigers. We design, make, and use highly effective methods, nasty weapons, innovative tools, and traps for this purpose.

Most life forms on Earth get their energy from the sun, and their nutrients from soil and rainwater. Plants use photosynthesis to capture sunlight, and herbivores eat those plants to obtain energy and nutrients essential for their survival. Carnivores eat the herbivores. The plant and animal corpses are consumed by hyenas, bacteria, fungi, worms and the like. The remainder becomes part of the soil (compost), on which new grass or fruit trees can grow.

In the pecking order, every species has a predator so that their population and ecosystem are controlled. It is only humans who don't have a predator. This is another reason why humans sit on top of the food chain. This privilege is not because we have the sharpest teeth or the biggest claws. It is due to our intelligence and ability to make weapons to defend against external threats.

The greatest threat to humans is often other humans. Some people are full of aggression, greed, and slyness in their character. Their actions can result in death, sometimes in very large numbers. Therefore, humans can be their own predators.

Humans are the only animals that can cooperate with each other in very complex and ingenious ways: socially, economically, flexibly, and in very large numbers. There are other social animals like ants and bees that can cooperate in large numbers, but their cooperation is limited and not as sophisticated as that of humans.

Humans have created sub-pecking orders - some powerful positions like army generals, field marshals, presidents, kings, and queens. These people are higher up in the pecking order than ordinary people on the street. Their shortcomings and bad decisions could potentially cause the death of millions of people.

Although we humans rule over all other animals, we are helpless when Nature sets hurricanes, pandemics, droughts, forest fires, and earthquakes upon us. Nature can be the most vicious

[552]https://www.npr.org/sections/thesalt/2013/12/08/249227181/between-pigs-and-anchovies-where-humans-rank-on-the-food-chain

predator of all, with the ability to kill millions - not only humans, but also other animals and plants through epidemics of plagues, smallpox, polio, tuberculosis, AIDS and others.

VII.13. Life is Part of a Dynamic System Which Evolves Continuously

Everything evolves continuously, including life itself. We can see clearly from every life form that life is a dynamic system. Each life form is part of a species, and each species is a member of a genus, tribe, sub-family, family, sub-order, order, class, phylum, and kingdom. If life was not part of a dynamic system, everything around us would be fixed and unchanging, as if time had stopped. As a matter of fact, we would never have come to exist.

A stagnant system becomes dynamic when external factors come into play. External factors impose variation into a stagnant system. If a variation is imposed on an existing biological species, this species must adapt to the new conditions. If it does not adapt, it is bound to die and go extinct. The external factors could lead to the formation of a new life form, or even a new species. If the imposed variation is weak, it could cause a mutation. This adds a new, albeit subtle, variation to that species.

Such external factors or variants can be anything which changes the existing environmental conditions, for example, a change in climate, drought, population overgrowth, a meteorite impact, or a new predator. Life really is a dynamic system, akin to a test tube experiment in a laboratory.

In chemistry, the addition of another reactant to the contents of a test tube, or application of different conditions like heat, pressure, or light, often leads to a change. This change in the test tube could either be the formation of a new product, disappearance of the existing product, or no change at all. Any variation imposed on the contents of the test tube is likely to spoil the existing equilibrium of the test tube. The variation can be good or bad, or better or worse. The resulting change always occurs due to a specific reason, often the chemical affinity between the original and newly added contents, as they seek to reach a new equilibrium, a state of minimum energy.

Externally imposed conditions can be harmful to the existing species. For example, our journey to create civilization and an ever-growing population affects Earth's climate by contaminating air, soil and water systems. The contents of the air we breathe will change when we release heat and greenhouse gases by burning coal, oil and gas - the fossil fuels which Nature tucked away underground millions of years ago to create that breathable atmosphere for us.

By now, we know that our journey to civilization has disturbed the equilibrium set by Nature. That is why we are experiencing more frequent and intense hurricanes, typhoons, floods, droughts, forest fires, and the melting of permafrost, glaciers, and polar ice caps. These changes add additional challenges beyond the cyclic and seasonal variations influenced by solar activities.

Life will attempt to adapt to these variations, but if they occur too rapidly and are irreversible, Earth could become inhospitable for our species, leading to mass extinctions. We don't know whether anything will survive such a worst-case scenario, and if so, whether more resilient fauna and flora, or another version of humanity, will emerge or replace us. However, without urgent reversal of this shift in equilibrium, the inhabitants of Earth are more likely to go extinct.

CHAPTER VIII. WHERE AND HOW DID LIFE EMERGE?

VIII.1. Requirements for Life to Come into Existence

Biological evolution on Earth is a relatively recent chapter in the overall history of the universe's evolution. To host life and initiate biological evolution, we first needed a universe with galaxies, stars, and suns, followed by planets with solid land, water, and breathable air. All these necessary requirements were met on Earth. Without the universe there would be no amino acids, no organic molecules, and no life. The universe supplied the ingredients for biological evolution: atoms of carbon, hydrogen, oxygen, nitrogen, and others. These atoms combined to form molecules such as amino acids, proteins, and fats, which formed tissues, organs, and living beings. This is the mainstream scientific belief about how we, and everything else, came into existence on Earth.

In its early days, Earth was inhospitable to any living organism, whether plant, fungus, bacteria, or animal. Several environmental conditions needed to align correctly for life to begin in its present form on Earth. These conditions included stable land, breathable air, a non-hostile climate, accessible water, energy in the form of ample sunshine, and limited ultraviolet radiation.

Earth met these prerequisites by being located at an optimal distance from the sun, receiving a moderate amount of radiation – not too much to be harmful, but not too little so that temperatures were too cold to sustain life. The 23.5-degree tilt of Earth's axis prevented extreme temperatures. The ozone layer in Earth's upper atmosphere shielded the planet from the sun's harmful ultraviolet radiation, and the Van Allen magnetic belt protected Earth from destructive solar winds that could strip away its thin atmosphere. Additionally, essential chemical elements such as carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, and trace elements were available in sufficient quantities in the air, water, and soil.

We may never be able to prove beyond reasonable doubt how exactly life first evolved. Most scientists believe that life emerged from the transformation of geochemistry to biochemistry. They have long explored several possible starting locations for the origin of life, including tidal pools, hot springs on land and under deep oceans, and even extra-terrestrial sources.

VIII.2. THE EXTRA-TERRESTRIAL ORIGIN HYPOTHESES

The extra-terrestrial origin hypothesis claims that some of the organic compounds essential for life were formed somewhere in outer space, and were transported to Earth by impacting comets and meteorites[553].

Evidence in support of this hypothesis has come from spectrometric measurements, actual samples, and those collected by spacecraft. This data is generally irrefutable. It demonstrates existence of varying amounts of complex carbon compounds, such as tholins,[554] in outer space.

Early data from 1940[555] identifies the presence of simple carbon-hydrogen and carbon-nitrogen molecules in interstellar space, by spectroscopic measurements. Later in 1963, the presence of interstellar oxygen and OH (hydroxyl) was discovered[556]. In 1969, H_2CO (formaldehyde), an organic molecule, was discovered as the first observed polyatomic molecule in interstellar space[557].

However, real tangible evidence comes from the Murchison meteorite that was observed landing in Australia in 1969 near Murchison, Victoria[558]. Chemical analysis of this uncontaminated meteorite showed the presence of over 90 different amino acids, 19 of which are found in living organisms of the Earth. This led the scientists to believe that the newly forming Earth was bombarded heavily by such comets and meteorites which possibly supplied these organic molecules, along with the water and atmospheric gases[559].

Additional tangible evidence was obtained when the European Space Agency's Rosetta probe, launched in 2004, detected several organic molecules in the gaseous tail of comet 67P/Churyumov–Gerasimenko. These included water, carbon monoxide, carbon dioxide, ammonia, methane, and methanol.

Over 100 species have so far been detected in the interstellar medium. These include radicals and ions, organic (carbon-based) compounds such as alcohols, acids, aldehydes, and ketones, kerogen-like carbon-rich solids, ice, and common gases like carbon monoxide, methane, hydrogen, and a

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553 https://evolution.berkeley.edu/evolibrary/article/0_0_0/origsoflife_03

554 Thompson WR, Murray BG, Khare BN, Sagan C (December 1987). *"Coloration and darkening of methane clathrate and other ices by charged particle irradiation: applications to the outer solar system"*. Journal of Geophysical Research. 92 (A13): 14933–47. *Bibcode* :*1987JGR....9214933T*. *doi*:*10.1029/JA092iA13p14933*. *PMID 11542127*.

555 McKellar, A. (1940). "Evidence for the Molecular Origin of Some Hitherto Unidentified Interstellar Lines." Publications of the Astronomical Society of the Pacific. 52 (307): 187. *Bibcode* :*1940PASP...52..187M*. *doi*:*10.1086/125159*

556 S. Weinreb, A. H. Barrett, M. L. Meeks & J. C. Henry (1963). "Radio Observations of OH in the Interstellar Medium." Nature. 200 (4909): 829–831. *Bibcode*:*1963Natur.200..829W*. *doi*:*10.1038/200829a0*. *S2CID 38569542*

557 Lewis E. Snyder, David Buhl, B. Zuckerman, and Patrick Palmer, 1969. Microwave Detection of Interstellar Formaldehyde. Phys. Rev. Lett. 22, 679 – Published 31 March 1969.

558 https://en.wikipedia.org/wiki/Murchison_meteorite

559 PIERAZZO, E.; CHYBA C.F. (2010). "Amino acid survival in large cometary impacts." Meteoritics & Planetary Science. 34 (6): 909–918. Bibcode:1999M&PS...34..909P. doi:10.1111/j.1945-5100.1999.tb01409.x

suite of complex gaseous carbon compounds called poly-aromatic compounds (like poly-aromatic hydrocarbons)[560].

Under interstellar medium conditions, polycyclic aromatic hydrocarbons can transform into more complex organics, through hydrogenation, oxygenation and hydroxylation reactions. These are steps involved in making amino acids and nucleotides - the raw materials of proteins and DNA, respectively[561]. Poly-aromatic hydrocarbons are widespread throughout the universe, and their existence is associated with the formation of stars and exoplanets following the Big Bang[562].

More tangible evidence for these organic compound findings comes from comet samples collected by spacecraft. The Stardust, a robotic space probe launched by NASA on 7 February 1999, brought dust samples from the coma[563] of comet Wild 2[564] back to Earth for analysis. These samples revealed a wide range of organic compounds, including two that contain biologically usable nitrogen, and aliphatic hydrocarbons with longer chain lengths than those observed in the diffuse interstellar medium. Additionally, the samples contained abundant amorphous silicate minerals such as olivine and pyroxene, along with limited pure carbon.

Furthermore, NASA scientists identified glycine, an amino acid and one of the fundamental chemical building blocks of life, in the material ejected from comet Wild 2, marking the first time glycine was captured directly from a comet by the Stardust probe. While glycine had previously been detected in meteorites and observed in interstellar gas clouds, the Stardust discovery is the first direct sampling from a comet (op. cit.).

More evidence comes from the comas[565] of comets C/2012 F6 and C/2012 S1, where astronomers identified hydrogen cyanide, hydrogen isocyanide, and formaldehyde for the first time[566]. In July 2015, the European Space Agency's Philae spacecraft detected 16 organic compounds on the

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[560] https://en.wikipedia.org/wiki/Astrochemistry

[561] Staff (September 20, 2012). "NASA Cooks Up Organics to Mimic Life's Origins". Space.com. Retrieved September 22, 2012.
Gudipati, Murthy S.; Yang, Rui (September 1, 2012). "In-Situ Probing of Radiation-Induced Processing of Organics In Astrophysical Ice Analogs – Novel Laser Desorption Laser Ionization Time-Of-Flight Mass Spectroscopic Studies." The Astrophysical Journal Letters. 756 (1): L24. Bibcode :2012ApJ...756L..24G. doi:10.1088/2041-8205/756/1/L24

[562] Hoover, Rachel (February 21, 2014). *"Need to Track Organic Nano-Particles Across the Universe? NASA's Got an App for That"* . *NASA. Retrieved February 22, 2014*.

[563] The coma is the nebulous envelope around the nucleus of a comet.

[564] https://en.wikipedia.org/wiki/Stardust_(spacecraft)

[565] The gas and dust create a huge, fuzzy cloud around the nucleus of a comet is called the coma.

[566] Zubritsky, Elizabeth; Neal-Jones, Nancy (August 11, 2014). *"NASA's 3-D Study of Comets Reveals Chemical Factory at Work"*. *NASA. Retrieved August 12, 2014*.
Cordiner, M.A.; et al. (August 11, 2014). "Mapping the Release of Volatiles in the Inner Comae of Comets C/2012 F6 (Lemmon) and C/2012 S1 (ISON) Using the Atacama Large Millimeter/Submillimeter Array." *The Astrophysical Journal*. 792 (1): L2. *arXiv*:*1408.2458*. *Bibcode*: *2014ApJ...792L...2C* . *doi*:*10.1088/2041-8205/792/1/L2*. *S2CID 26277035*

surface of comet 67/P. Four of these were observed for the first time on a comet: acetamide, acetone, methyl isocyanate and propionaldehyde[567].

More recently, the Hayabusa2 spacecraft physically landed on and collected samples from the asteroid Ryugu on February 22, 2019. The samples were delivered to Earth on December 6, 2020. They were prepared in Japan in July 2021, and analysed at Goddard Space Flight Centre in the U.S.A in the autumn of 2021[568]. The analyses showed that asteroid Ryugu was rich in organic molecules. This once again proved the extra-terrestrial origin of organic material from space without any doubt. The sample from Ryugu contained many types of organics which form in the presence of liquid water, including aliphatic amines, carboxylic acids, polycyclic aromatic hydrocarbons, and nitrogen-containing heterocyclic compounds [(op. cit.)]. The mission found out that the prebiotic molecules in deeper, unexposed parts of Ryugu were protected from the harsh environmental conditions of space.

Samples collected from meteorites and asteroids show that organic matter can survive the harsh conditions of space, providing substantial tangible evidence to support this claim. The discovery of interstellar formaldehyde and other molecules like glycine in a comet supports the idea that the fundamental building blocks of life are prevalent in space, and that the basic molecular components of life could have come from extra-terrestrial sources.

The Panspermia hypothesis claims that microbes, viruses, or bacteria "hitched" a ride on fragments of a planet hit by a large meteorite. Supporters of this hypothesis believe that the seeds of life, alien bacteria and viruses, may still be raining down upon us[569,570], but no living organism, even the simplest form of bacteria or virus or fungi, has been found in any extra-terrestrial material so far. Could this be due to the fiery passage (up to 1400 ^{o}C) through Earth's atmosphere? We do not know. However, this idea was explored by Russian scientists, who proved that bacteria can indeed survive such harsh conditions. A test was conducted by drilling holes into the heat shield of an unmanned space probe coming back from the Space Station, and inserting pieces of rocks inoculated with microbes. It was demonstrated that some of the microbes survived the fiery passage through the Earth's atmosphere, albeit partially - the ones which survived were from the deeper part of the test zone, where they were insulated from excessive heat[571].

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[567] https://www.smithsonianmag.com/smart-news/philae-spacecraft-confirmed-presence-organic-molecules-comet-it-landed-180953379/

[568] https://phys.org/news/2023-02-ryugu-asteroid-sample-reveals-organic-rich.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

[569] https://listverse.com/2016/12/15/10-diseases-that-possibly-came-from-outer-space/

[570] https://astronomy.stackexchange.com/questions/13147/is-it-possible-for-a-virus-to-come-from-a-meteorite

[571] https://iview.abc.net.au/show/chemical-world/series/1/video/DO1952H001S00

In 2017, Peter Dockrill[572] reported that a prominent Russian cosmonaut, Anton Shkaplerov, used cotton swabs to wipe over the exterior of the International Space Station (ISS) and detected an unidentified life-form that was absent during the ISS module's launch. However, the possibility of contamination from Earth was not ruled out, considering that tiny bacteria known as tardigrades are known to survive for extended periods in harsh conditions,(op. cit.) including exposure to the cold vacuum of outer space. Their DNA can withstand a battering by X-ray radiation[573]. Nonetheless, tardigrades require water to live, grow, and reproduce, which is not readily available in space.

In summary, while the idea of extraterrestrial origins is plausible in terms of providing life-starting organic molecules, there is no evidence so far found of a living (or semi-living) organism being brought to Earth to start life.

VIII.3. Terrestrial Origin - Deep-Sea Hydrothermal Vents and the Little Pond Hypotheses

The Terrestrial Hypotheses, grounded in down-to-earth ideas, propose that life originated from hydrogen, carbon, oxygen and nitrogen (H, C, O, N) in environments where energy and chemical affinity facilitated their combination into molecules. Two prominent explanations among many proposed are:

1. Life evolved in hydrothermal vents deep under the sea, and

2. Life evolved on land in little ponds near geysers, where chemical reactions were driven by ultraviolet energy from sunlight, redox-coupling reactions, and lightning strikes.

VIII.3.A. Deep-Sea Hydrothermal Vents

Most scientists today believe that life originated in an alkaline environment near deep-sea hydrothermal vents, otherwise referred to as hydrothermal springs and black smoker chimneys. This idea was inspired by the present-day hydrothermal vents, geysers, and hot springs of the ocean floor[574]. Present day deep-sea hydrothermal vents represent a high temperature-pressure environment, where an abundant supply of energy is available.

The first actual deep-sea hydrothermal vent was discovered in 1977, during exploration of the Galápagos Rift along the mid-ocean ridge in the eastern Pacific Ocean. Here tectonic plates spread apart, allowing magma to rise and cool, forming a new crust and volcanic mountain chains. When

[572] https://www.sciencealert.com/living-bacteria-from-outer-space-found-clinging-to-iss-alien-life
[573] https://cen.acs.org/biological-chemistry/biochemistry/tardigrades-survive-space/97/i41
[574] https://evolution.berkeley.edu/evolibrary/article/0_0_0/origsoflife_03

the temperature of deep-ocean water suddenly changes from near freezing to 400 °C in a short distance, a thermal gradient suitable for life to evolve is created.

Exploratory studies in these locations have revealed hydrothermal vents sustain a vibrant ecosystem, with hundreds of rare species living around them. Despite the extreme temperatures, pressures, toxic environment, and lack of sunlight, life thrives at the bottom of the ocean.

These studies also demonstrated that bacteria were highly abundant and actively converting inorganic, toxic gases from the vents, such as SO_x, H_2, H_2S, CN^-, NH_4^+, CO, CH_4, and CH_3SH,[575] into usable forms of energy through chemosynthesis. This process serves as a vital source of food for other organisms living around the vents.

These findings inspired scientists to propose that life could have originated in a similar environment during the early days of Earth. It is generally believed that the necessary chemicals for initiating life were present on Earth during its early stages. By examining DNA sequences from modern organisms, biologists have tentatively traced the most recent common ancestor of all life as an aquatic microorganism that lived in extremely high temperatures, making it a likely candidate for a hydrothermal vent inhabitant[576].

It is believed that hot springs on the ocean floor, in contact with newly formed basic and ultramafic rocks, leached olivine from these rocks resulting in a warm alkaline fluid rich in hydrogen, carbon dioxide, sulphides, and other chemicals. This process also led to the precipitation of porous solids such as carbonate rocks (like dolomite[577], anhydrite, magnesite, or siderite), forming vents resembling termite mounds but deep beneath the ocean.

The interaction between acidic[578] ocean water and hot hydrothermal fluids produced iron-sulphur bubbles, which played a crucial role in the emergence of life by trapping hydrogen and carbon dioxide gases. The reaction of these gases with phosphorus produced various organic molecules, including acetyl phosphate and pyrophosphate, which act similarly to adenosine triphosphate (ATP), the chemical which powers living cells.

These hydrothermal vents hosted a variety of chemicals, including amino acids, nucleotides, pantoyl lactone, β-alanine, and cysteamine. The latter three components were essential for creating pantetheine, a precursor to coenzyme A, which is a building block for RNA and DNA. The formation

[575] Methyl mercaptan is a colourless gas with a smell like rotten cabbage.

[576] https://evolution.berkeley.edu/evolibrary/article/0_0_0/origsoflife_03

[577] https://www.newscientist.com/article/dn17987-how-life-evolved-10-steps-to-the-first-cells/

[578] Acidity is the result of the dissolution of large amounts of CO2 into the ocean water. Silicate minerals such as olivine forsterite and plagioclase can react with acidic waters and form alkaline phases like carbonate minerals.

of pantetheine required temperatures of around 40 °C, which were attainable a short distance away from the vents.

When these bubbles burst, they precipitated as iron-sulphide minerals like pyrrhotite and marcasite, which acted as catalysts in the synthesis of some of the organic reactions. The nucleotides facilitated the formation of RNA, DNA, and proteins. It is hypothesised that the earliest organic cells, known as protocells, were lipid-coated structures that enclosed iron-sulphur bubbles containing self-replicating molecules.

Another milestone in the formation of a living cell was the formation of an enzyme called pyrophosphatase, which catalyses the production of pyrophosphate. Pyrophosphate enabled protocells to extract more energy from the temperature gradient between the hot alkaline vent fluid and the cold acidic ocean. This energy extraction process was perfected with the creation of triphosphates, which reacted with adenosine to form ATP - the single most important molecule in biology. With ATP, protocells could establish their own electrochemical gradient, freeing them from reliance on the vents and allowing them to move around. Cells left the vents on two separate occasions, leading to the emergence of bacteria and archaea. Archaea are single-celled organisms similar to bacteria, but markedly distinct in molecular organisation[579].

Kurakin[580] suggested that the environmental conditions on early Earth were conducive to a Fischer-Tropsch-type (FTT) reaction, which may have facilitated the evolution and expansion of diverse organic materials - the precursor of LUCA (Last Universal Common Ancestor).

The FTT reaction involves converting a mixture of carbon monoxide and hydrogen into liquid hydrocarbons, specifically organic C-H molecules. These reactions typically occur at temperatures ranging from 150–300 °C in the presence of metal catalysts such as cobalt, nickel, or iron, at pressures ranging from one to several tens of atmospheres[581]. The ideal FTT reaction that forms alkane and water is:

$(2n + 1)H_2 + nCO \rightarrow C_nH_{2n+2} + nH_2O$ where $n = 10$ to 20.

However, in addition to alkanes, small amounts of alkenes, alcohols, and other oxygenated hydrocarbons were produced in these reactions[582]. Organic molecules like hydrocarbons may have been preserved as deposits in high-pressure, low-temperature environments. This claim was

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[579] https://www.newscientist.com/article/dn17987-how-life-evolved-10-steps-to-the-first-cells/ 6 July 1996

[580] Kurakin, A. The self-organizing fractal theory as a universal discovery method: the phenomenon of life. *Theor Biol Med Model* 8, 4 (2011). https://doi.org/10.1186/1742-4682-8-4

[581] https://en.wikipedia.org/wiki/Fischer-Tropsch_process

[582] Kaneko, Takao; Derbyshire, Frank; Makino, Eiichiro; Gray, David; Tamura, Masaaki (2001). "Coal Liquefaction." Ullmann's Encyclopedia of Industrial Chemistry. Weinheim: Wiley-VCH. *doi:10.1002/14356007.a07_197*. *ISBN 9783527306732*.

supported by the abundant deposits of methane clathrates found in seabeds and permafrost on Earth. Recent analysis of the stable carbon and hydrogen isotopic composition of hydrocarbons of the Lost City[583], a hydrothermal field in the Atlantic Ocean, supports this notion. At the Lost City, hydrocarbons are produced abiotically in submarine vents, most likely though Fischer-Tropsch-type reactions[584,585].

Submarine vents form geysers which erupt at lower temperatures, surrounded by largely alkaline waters. The interaction occurs when descending acidic ocean water reacts with minerals from ultramafic rocks, turning alkaline and rising to the surface through these deep-sea mounds.

Submarine vents form geysers which erupt at lower temperatures, surrounded by largely alkaline waters. The interaction occurs when descending acidic ocean water reacts with minerals from ultramafic rocks, turning alkaline and rising to the surface through these deep-sea mounds.

This alkalinity arises from the reaction of acidic seawater with olivine ($(Mg, Fe)_2SiO_4$), a dominant mineral in ultrabasic rocks, commonly found on the seafloor. Olivine would have been even more abundant in the early Earth, before the crust thickened. This reaction produces serpentine, a new mineral, and releases hydrogen, alkaline fluids, and heat, reaching temperatures around 120°C and creating a porous labyrinth of rocks[586,587]. These porous rocks within the vents are believed to have concentrated large organic molecules, making the vents an ideal setting for the "RNA World[588]", widely believed to have preceded the first cells.

Hydrothermal vents form in chemosynthetic ecosystems, where chemical compounds serve as the energy source rather than light. Modern hydrothermal vents demonstrate that these systems can support vast amounts of life[589].

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583 Location of Lost City in the Mid-Atlantic Ridge at a depth of -750 to -900 metres. It covers an area of 500 m2. Source: https://en.wikipedia.org/wiki/Lost_City_Hydrothermal_Field

584 The Lost City Hydrothermal Field, often referred to simply as Lost City, is an area of marine alkaline hydrothermal vents located on the Atlantis Massif at the intersection between the Mid-Atlantic Ridge and the Atlantis Transform Fault, in the Atlantic Ocean. It is a long-lived site of active and inactive ultramafic-hosted serpentinization, abiotically producing many simple molecules such as methane and hydrogen which are fundamental to microbial life. As such it has generated scientific interest as a prime location for investigating the origin of life on Earth and other planets similar to it.[2] https://en.wikipedia.org/wiki/Lost_City_Hydrothermal_Field

585 Proskurowski G, Lilley MD, Seewald JS, Fruh-Green GL, Olson EJ, Lupton JE, Sylva SP, Kelley DS: Abiogenic hydrocarbon production at lost city hydrothermal field. Science. 2008, 319: 604-607. 10.1126/science.1151194.

586 M. Le Page and Nick Lane 14 Oct. 2009 How life evolved: 10 steps to the first cells. New Scientist, issue 2730 , published 17 October 2009
https://www.newscientist.com/article/dn17987-how-life-evolved-10-steps-to-the-first-cells/

587 Nick Lane, 2009. Was our oldest ancestor a proton-powered rock? New Scientist, No. 2730, pp. 38-42. http://www.esalq.usp.br/lepse/imgs/conteudo_thumb/Was-our-oldest-ancestor-a-proton.pdf

588 We will discuss it in the next chapter.

589 Ramirez-Llodra, E; Keith, DA (2020). *"M3.7 Chemosynthetic-based-ecosystems (CBE)"*. In Keith, D.A.; Ferrer-Paris, J.R.; Nicholson, E.; Kingsford, R.T. (eds.). The IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem

VIII.3.B. THE LITTLE POND AND PRIMORDIAL SOUP HYPOTHESIS

The little pond hypothesis suggests that life originated from nonliving matter, in a little pond on the surface of Earth. The idea first appeared in 1864–1867 in Herbert Spencer's *Principles of Biology*. In 1879, William Turner Thiselton-Dyer referred to the idea in a paper entitled *On spontaneous generation and evolution*[590].

On 1 February 1871, Charles Darwin wrote to Joseph Hooker, sharing his own speculations inspired by their publications. Darwin[591] suggested that the original spark of life may have begun in a warm little pond, containing various ammonia and phosphoric salts, light, heat, and carbon. He hypothesised that a protein compound could have been chemically formed and subsequently evolved into more complex compounds. Studies in 2017 supported the idea that life may have begun shortly after Earth formed, with RNA molecules emerging in these "warm little ponds"[592].

According to Jack W Szostak[593], a warm little pond environment would facilitate the formation of protocells and template copying due to its rich nutrient content, including nucleotides, and alternating energy gradients from short intervals of hot and cold temperatures. In such an environment, organic compounds would accumulate to high concentrations, especially in geothermally active regions around active volcanoes, where fatty acids and related compounds might be synthesised by electrical discharges like lightning. *"Sulphurous exhalations such as COS (carbonyl sulphide) and H_2S (hydrogen sulphide) could be important for the synthesis of thioesters or N-carboxyanhydrides for re-activation chemistry, and for the synthesis of modified nucleosides such as 2-thiouridine for improved rate and fidelity of RNA replication"* (op.cit.).

Another terrestrial idea is the Primordial Soup Hypothesis, proposed by Alexander Oparin in 1924 and independently by John Haldane in 1925. This hypothesis suggests that when energy in the form of heat, lightning, or UV rays from sunlight, is added to atmospheric gases (reducing gases), it results in the formation of organic molecules in pools of shallow surface waters.

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functional groups. Gland, Switzerland: IUCN. *doi* :*10.2305/IUCN.CH.2020.13.en*. *ISBN 978-2-8317-2077-7*; https://en.wikipedia.org/wiki/Hydrothermal_vent

590 https://en.wikipedia.org/wiki/Abiogenesis

591 "Letter no. 7471, Charles Darwin to Joseph Dalton Hooker, 1 February (1871)". Darwin Correspondence Project. *Retrieved 7 July 2020*.
Marshall, Michael (11 November 2020). "Charles Darwin's hunch about early life was probably right - In a few scrawled notes to a friend, biologist Charles Darwin theorised how life began. Not only was it probably correct, his theory was a century ahead of its time". BBC News. Retrieved 11 November 2020.

592 Johnston, Ian (2 October 2017). *"Life first emerged in 'warm little ponds' almost as old as the Earth itself – Darwin's famous idea backed by new scientific study"*. *The Independent*. *Archived* from the original on 3 October 2017. *Retrieved 2 October 2017*.

593 https://molbio.mgh.harvard.edu/szostakweb/publications/Szostak_pdfs/Szostak_2012_JSystChem.pdf

Oparin suggested that molecules central to life, such as sugars and amino acids, could have formed in these near-surface waters. The expectation was that the chemicals would form globular structures like oil forming a layer on top of water. If you watch such structures under a microscope, they behave unnervingly like living cells. They grow and change shape, and sometimes divide into two. They can also take in chemicals from the surrounding water, so life-like chemicals can become concentrated inside them. Oparin proposed that these were the ancestors of modern cells.

In 1924, Oparin published his book *The Origin of Life*[594]. In this book he set out a vision for the birth of life that was startlingly like Darwin's warm little pond[595]. Just like Oparin, Haldane outlined how organic chemicals could build up in water and reach a consistency of hot dilute soup. The expectation was that this would be the place for the first living or half-living beings to form.

Although the Primordial Soup was a neat and compelling idea, there was no experimental evidence to back it up. It took 28 years for it to be proven (partially) by experiment in the laboratory and we will discuss this next.

In summary, the organic molecules, monomers, and polymers, would gather in places such as tide pools, hot springs, or deep-sea ocean vents, to make the life-making '*soup*'. Each of these areas contained their source of energy, which would allow the chemical reactions to continue. Tide pools had UV rays, which, in that early atmosphere. Hot springs and ocean vents provided geothermal heat to drive the reactions. The hypothesis suggests that over time, monomers would bond to form polymers in various locations (shorelines, lagoons, under the sea, or oceanic vents), and these polymers would eventually undergo further transformations to form living cells.

VIII.4. Attempts to Make Living Cell from Inanimate Precursors in the Laboratory

In 1952, a doctoral student named Stanley I Miller, under the supervision of Prof. Urey, carried out the most famous experiment ever attempted regarding the origin of life. The experimental set-up was simple, as shown in figure below. It involved[596] trapping methane, ammonia, hydrogen, and water, in a sealed 5 litre glass flask which was connected to a 0.5 litre flask half-filled with sea water.

The sea water in the smaller flask was heated to boil, allowing the water vapour to enter the larger flask. Electrical sparks were fired between electrodes to simulate lightning in the water vapour and

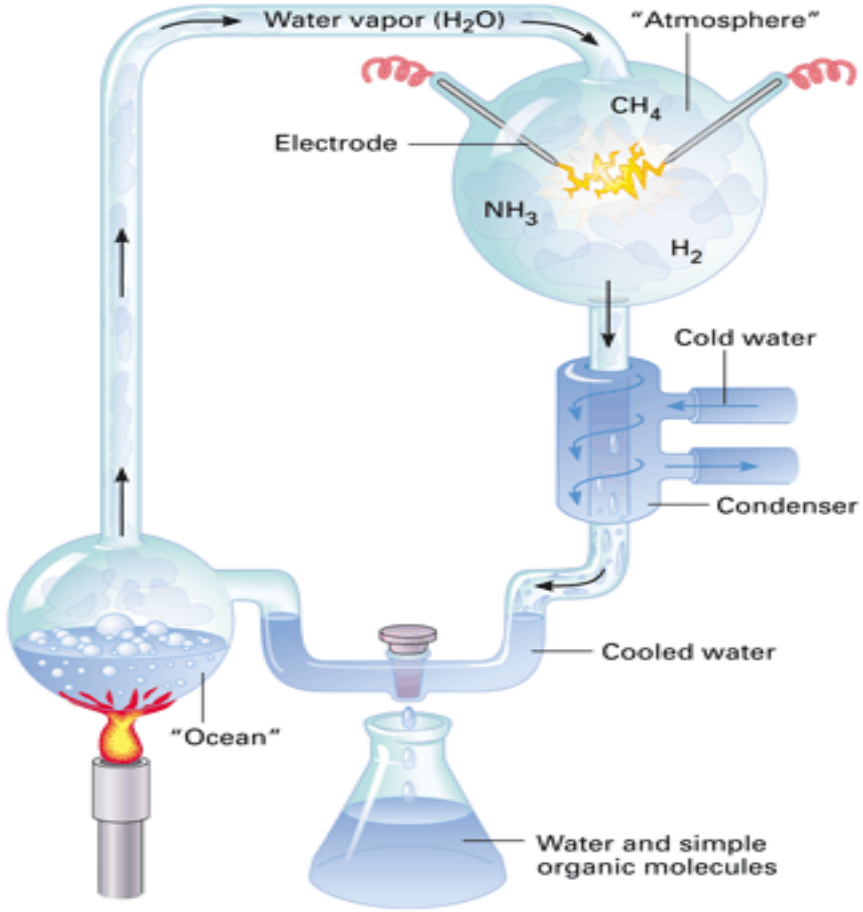
[594] https://www.valencia.edu/~orilife/textos/The%20Origin%20of%20Life.pdf

[595] How did life get started? By Michael Marshall, 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

[596] https://en.wikipedia.org/wiki/Miller%E2%80%93Urey_experiment .

gaseous mixture, and then the simulated atmosphere was cooled again so that the water condensed and trickled into a U-shaped trap at the bottom of the apparatus.

To his delight, Miller found that *"the water in the flask became noticeably pink after the first day, and by the end of the week the solution was deep red and turbid*[597]*, in the form of a racemic mixture*[598] *of organic compounds, including amino acids, which are the building blocks of proteins"* - indicating that a soup-like mix of chemicals had formed.



Simulating Earth's ancient atmosphere, oceans, and sources of energy, Stanley Miller's experiment produced some of the organic compounds that are essential for life. Source[599].

The boiling flask was then removed, and mercuric chloride was added to prevent microbial contamination. The reaction was stopped by adding barium hydroxide and sulphuric acid, and then

[597] Miller, Stanley L. (1953). "Production of Amino Acids Under Possible Primitive Earth Conditions'' (PDF). Science. 117 (3046): 528–9. Bibcode: 1953Sci... 117.. 528M. doi:10.1126/science.117.3046.528. PMID 13056598. Archived from the original (PDF) on 2012-03-17. Retrieved 2011-01-17.

[598] a chemical mixture that contains equal quantities of clockwise and anticlockwise rotatory forms of a compound.

[599] Stanley L. Miller, 1953. A Production of Amino Acids Under Possible Primitive Earth Conditions. Science 15 May 1953: Vol. 117, Issue 3046, pp. 528-529, DOI: 10.1126/science.117.3046.528 ; https://science.sciencemag.org/content/117/3046/528

evaporated to remove impurities. Using paper chromatography, Miller identified five amino acids present in the solution: glycine, α-alanine and β-alanine were positively identified, while aspartic acid and α-aminobutyric acid were less certain due to the spots being faint[600]. Glycine and alanine, both amino acids, are often described as the building blocks of life (see Column 2 in **Table 4**). These amino acids are the proteins which control most biochemical processes in our bodies.

Miller had successfully made some of life's most important components from scratch. This supported Alexander Oparin and J. B. S. Haldane's hypothesis that presumed conditions prevailing on the primitive Earth could synthesise more complex organic compounds from simpler inorganic precursors.

Miller's experiment therefore provided direct experimental support for the Primordial Soup theory[601]. The results of this classic 1952 experiment were published under only Miller's name in 1953[602], and the study is often known as the "Miller-Urey experiment." In a 1996 interview, Stanley Miller said: *"Just turning on the spark in a basic prebiotic experiment will yield 11 out of 20 amino acids"*[603]. The original apparatus used to conduct this experiment is on display at the Denver Museum of Nature and Science[604].

Sometime later, previously unreported archived samples of Miller experiments were found. These samples were used to test different environmental conditions, such as simulating volcanic eruptions in hot spots or island arc-type systems (column 3 of Table 4) and hydrogen sulphide-rich environments (**column 4 of Table 4**).

In 2011, analyses of archived samples from the Miller-Urey experiments[605], using modern techniques like high-performance liquid chromatography and time-of-flight mass

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600 https://en.wikipedia.org/wiki/Miller%E2%80%93Urey_experiment and Miller, Stanley L. (1953). *"Production of Amino Acids Under Possible Primitive Earth Conditions" (PDF). Science*. 117 (3046): 528–9. *Bibcode* :*1953Sci...117..528M*. *doi*:*10.1126/science.117.3046.528*. *PMID 13056598*. Archived from *the original (PDF)* on 2012-03-17. *Retrieved 2011-01-17*

601 "The Spark of Life". *BBC Four*. 26 August 2009. Archived from the original on 2010-11-13. TV Documentary.

602 Miller, Stanley L. (1953). "Production of Amino Acids Under Possible Primitive Earth Conditions". Science. 117 (3046): 528–529. Bibcode:1953Sci...117..528M. doi:10.1126/science.117.3046.528. PMID 13056598.

603 *"Exobiology: An Interview with Stanley L. Miller"*. Accessexcellence.org. Archived from *the original* on May 18, 2008. *Retrieved 2009-08-20*.

604 https://en.wikipedia.org/wiki/Miller_Urey_experiment .

605 Parker, ET; Cleaves, HJ; Dworkin, JP; et al. (February 14, 2011). *"Primordial synthesis of amines and amino acids in a 1958 Miller H2S-rich spark discharge experiment"*. Proceedings of the National Academy of Sciences. 108 (14): 5526–31. *Bibcode*:*2011PNAS..108.5526P*. *doi*: *10.1073/pnas.1019191108* . *PMC 3078417*. *PMID 21422282*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3078417/

Table 4. The chemical analyses of the original and other archived Miller-Urey samples. Further information on each of the chemicals listed in column one can be obtained from Wikipedia.

Amino acid	Produced in experiment		
	Miller–Urey (1952)	Volcanic spark discharge (2008)	H_2S-rich spark discharge (2010)
Glycine	✓	✓	✓
α-Alanine	✓	✓	✓
β-Alanine	✓	✓	✓
Aspartic acid	✓	✓	✓
α-Aminobutyric acid	✓	✓	✓
Serine	X	✓	✓
Isoserine	X	✓	✓
α-Aminoisobutyric acid	X	✓	✓
β-Aminoisobutyric acid	X	✓	✓
β-Aminobutyric acid	X	✓	✓
γ-Aminobutyric acid	X	✓	✓
*Val*ine	X	✓	✓
Isovaline	X	✓	✓
Glutamic acid	X	✓	✓
Norvaline	X	✓	X
α-Aminoadipic acid	X	✓	X
Homoserine	X	✓	X
2-Methyl Serine	X	✓	X
β-Hydroxyaspartic acid	X	✓	X
Ornithine	X	✓	X
2-Methylglutamic acid	X	✓	X
*Phenyla*lanine	X	✓	X
Homocysteic acid	X	X	✓
S-Methylcysteine	X	X	✓
*Methio*nine	X	X	✓
Methionine sulfoxide	X	X	✓
Methionine sulfone	X	X	✓
*Isole*ucine	X	X	✓
*Leu*cine	X	X	✓
Ethionine	X	X	✓
Cysteine	X	X	X
*Histid*ine	X	X	X
*Lysi*ne	X	X	X
Asparagine	X	X	X
Pyrrolysine	X	X	X
Proline	X	X	✓
Glutamine	X	X	X
Arginine	X	X	X
*Threo*nine	X	X	✓
Selenocysteine	X	X	X
*Trypt*ophan	X	X	X
Tyrosine	X	X	X

spectrometry, identified primary amine-containing compounds produced via spark discharge in a gaseous mixture of H_2S, CH_4, NH_3, and CO_2. A total of 23 out of 24 amino acids and 4 amines, including 7 organo-sulphur compounds, were detected in the samples (see column 3 in Table 4). Once amino acids were formed, they were expected to accumulated in tidal areas, where they could be polymerized by carbonyl sulphide, a simple volcanic gas known to form peptides under mild conditions[606,607].

The data in Table 4[608] shows that 5 of the essential amino acids were made during H_2S-rich spark discharge experiments. Of the 9 essential amino acids only 3 were not detected in these three sets of experiments: tryptophan, histidine, and lysine. The Miller-Urey experiments inspired other scientists to create simple biological molecules from scratch. These new experiments also yielded similar results, showing that complex molecules could have formed under the conditions present on early Earth[609]. They were able to produce all 20 amino acids, several sugars, lipids, the nitrogenous bases found in DNA and RNA, and even ATP - the organic compound crucial for providing energy to sustain cellular functions.

For much of human history, the prevailing belief was that living beings were created by the gods, and alternative explanations were considered inconceivable. It is only in the last century that scientists began to challenge this view[610] and explore how life might have originated naturally, aiming to recreate the genesis moment in their laboratories. Michael Marshall[611] said: *"By the early 1950s, scientists had moved away from the long-standing assumption that life was a gift from the gods. They had instead begun to explore the possibility that life formed spontaneously and naturally on the early Earth – and thanks to Stanley Miller's iconic experiment, that provided some tangible support for the idea."*

While the Miller-Urey experiments were important and ground breaking, they did not create a living cell. The aim of the experiments was to demonstrate that essential components of a living cell could be made from inorganic materials, rather than to produce a fully functional living organism.

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606 https://en.wikipedia.org/wiki/Miller-Urey_experiment

607 Johnson AP, Cleaves HJ, Dworkin JP, Glavin DP, Lazcano A, Bada JL (October 2008). "The Miller volcanic spark discharge experiment." Science. 322 (5900): 404. Bibcode :2008Sci...322..404J. doi:10.1126/science.1161527. PMID 18927386.
- "'Lost' Miller–Urey Experiment Created More Of Life's Building Blocks". Science Daily. October 17, 2008. Archived from the original on October 19, 2008.

608 https://en.wikipedia.org/wiki/Miller-Urey_experiment

609 https://evolution.berkeley.edu/evolibrary/article/0_0_0/origsoflife_03

610 Like Wöhler challenged the Vitalist view and made urea in the lab from two common chemical compounds. See Chapter V.2

611 How did life get started? By Michael Marshall, 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

Next, we will explore the challenge of creating a living cell in the laboratory, which was taken on by the next generation of scientists. Some of the major scientific achievements are discussed by Stephanie Pappas (2013)[612] and various Wikipedia links[613] provide a detailed account of experiments and references where the aim was to create organic molecules which could be precursor of living organisms. This section presents the progress made in a chronological order. The information presented here has made extensive use of S. Papas' work and the references listed in Wikipedia[614].

- In 1869, Swiss physician Johannes Friedrich Miescher became the first scientist to isolate nucleic acid, the active ingredient of DNA.
- In 1903, geneticist Walter Sutton discovered that chromosomes occur in pairs and separate during meiosis[615], providing a vehicle for a mother and father to pass on their genetic material. These findings were published in a paper by Sutton in 1903[616].
- In 1941, geneticists Edward Tatum and George Beadle showed for the first time how genes direct metabolism in cells, and how mould on bread mutates when exposed to X-rays. They were awarded the Nobel Prize for this discovery in 1958.
- In the mid-1900s, scientists were aware of the link between chromosomes and had developed a good understanding of heredity. They also knew that DNA was the molecule responsible for carrying genetic information - the next steps were to find out what this molecule looked like.
- In 1950, Erwin Chargaff discovered that the building blocks of DNA (nucleotides) occur in specific patterns and was represented by four letters, A, T, G and C. These letters are the initials of the four different nucleobases: adenine, thymine, guanine, and cytosine. Chargaff was the first scientist to discover that no matter the species, A and T always appeared in equal measures, as did G and C. Adenine and guanine are nitrogenous bases known as purines, and have a fused-ring skeletal structure derived from purine. The T, C and U (uracil) are pyrimidine nucleobases and simple ring molecules.
- In 1953, James Watson and Francis Crick were the first to describe the structure and double helix shape of DNA. Crick referred to this discovery as *"the secret of life."*

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612 Stephanie Pappas (2013) Unraveling the Human Genome: 6 Molecular Milestones. https://www.livescience.com/26505-human-genome-milestones.html

613 https://en.wikipedia.org/wiki/Abiogenesis

614 This section largely benefitted from Wikipedia: https://en.wikipedia.org/wiki/Artificial_cell and How did life get started? By Michael Marshall, 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

615 Meiosis is a special type of cell division of germ cells in reproductive organisms.

616 "The Chromosomes in Heredity" https://www.journals.uchicago.edu/doi/pdfplus/10.2307/1535741

As the secrets of DNA began to unravel, scientists focussed on tackling genomics - studying the complete genetic library of organisms.

- In the 1950s and 1960s, Sidney Fox[617] studied the spontaneous formation of peptide structures (small chains of amino acids) under conditions that might have existed early in Earth's history. In an experiment to set the conditions suitable for life to form, Fox collected volcanic material from a cinder cone in Hawaii. He discovered that the temperature was over 100°C just 10 cm beneath the surface of the cinder cone, and suggested that this might have been the environment in which life was created, as molecules could have formed and then been washed through the loose volcanic ash into the sea. Fox placed lumps of lava over amino acids derived from methane, ammonia, and water, sterilised all the materials, and baked the lava over the amino acids for a few hours in a glass oven. A brown, sticky substance formed over the surface, and when the lava was drenched in sterilised water, a thick, brown liquid leached out. Fox demonstrated that amino acids would convert to long and often cross-linked, thread-like, sub-microscopic polypeptide molecules as they dried[618].
- In 1961, it was shown that the nucleic acid purine base adenine could be formed by heating aqueous ammonium cyanide solutions[619].
- In 1977, researchers sequenced the complete genome of a little virus (bacteriophage)[620] known as Phi X 174 for the first time.
- Between 1972 and 1973, U.S. biochemists Herbert Boyer and Stanley Cohen developed a technique to cut pieces of DNA in certain places, and then attach these pieces to the DNA of other organisms[621].
- In 1988, scientists inserted genes into soybeans, ultimately creating the first genetically modified crop (op.cit..). This was followed by other genetically modified crops, including potato, cotton, canola, rice, sugar beets, sugarcane, tomatoes and many more.

By the 1990's, scientists knew that every living being on Earth is made of cells, and all the essentials of life were stored within cells. They realised that they were structurally far more complex than red blood cells or a genetically modified tomato.

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617 https://en.wikipedia.org/wiki/Abiogenesis

618 Walsh, J. Bruce (1995). *"Part 4: Experimental studies of the origins of life"*. Origins of life (Lecture notes). Tucson, AZ: *University of Arizona*. Archived from *the original* no 13 January 2008. *Retrieved 8 June 2015*

619 *Oró, Joan* (16 September 1961). "Mechanism of Synthesis of Adenine from Hydrogen Cyanide under Possible Primitive Earth Conditions." Nature. 191 (4794): 1193–1194. *Bibcode :1961Natur.191.1193O*. *doi:10.1038/1911193a0*. *PMID 13731264*. *S2CID 4276712*.

620 A virus which infects bacteria

6217 https://www.medicaldaily.com/brief-history-genetically-modified-organisms-prehistoric-breeding-modern-344076

A cell is essentially a mushy ball, with a tough outer wall called a membrane, which keeps its inner contents inside the cell. These contents include the cytoplasm: a thick, clear, jelly-like substance; and the cell organelles such as the nucleus, endoplasmic reticulum, vacuoles, mitochondria, and ribosomes[622]. In the early days of Earth, somehow these components were all assembled and the first cell was created. It became obvious that a cell which was missing any of these components could not function properly. It might be able to divide into daughter cells, but it could not pass on any information about itself to its offspring. To do so requires RNA, DNA and genes. A cell is indeed a very complex structure - an amazing chemical factory in its own right.

In the early 2000s, scientists began to completely catalogue the human genome.

- In 2000, Craig Venter led a team that sequenced the human genome - the blueprint for life. The J. Craig Venter Institute (JVCI) team successfully synthesised a small bacterial genome, however their attempts to activate that genome in a cell failed.
- In 2001, The Human Genome Project achieved sequencing of the complete human genome. This was an international effort which took 13 years to complete. The project found that humans have approximately 23,000 protein-coding genes, which is only a mere 1.5% of the total genome. Surprisingly, it was found that our DNA contained mostly repeating sequences which were thought to have no function at all, and which did not code for any proteins.
- In 2001, Jack W Szostak et.al. [623] wrote in Nature magazine that it should be possible to make simple living cells from scratch, by replicating RNA in a simple, fatty blob. Two years later, they announced a major success in their experiments with vesicles (spherical blobs, with two layers of fatty acids on the outside and a central core of liquid). In an attempt to speed up the creation of vesicles, they added small particles of montmorillonite (common clay). Acting as a catalyst, the clay made the vesicles form 100 times faster - just like an enzyme would. Furthermore, the vesicles could absorb both montmorillonite particles and RNA strands from the clay surface. Montmorillonite forms from the weathering of volcanic ash, and was expected to have been abundant in the days of early Earth. They hypothesised that a volcanic land covered with montmorillonite clay could have been a suitable site for the first emergence of life.
- In 2003, Smith H.O, Hutchison C.A, Pfannkoch C, Venter J.C[624] from JVCI announced that they had successfully synthesised a small virus which infects bacteria[625]. They established

[622] How did life get started? By Michael Marshall, 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

[623] Szostak JW, Bartel DP, Luisi PL: Synthesizing life. Nature 2001, 409:387-390.

[624] Craig Venter is a prominent American biologist and entrepreneur known for his significant contributions to human genome sequencing and his pioneering work in synthetic life. Venter and his team created the first synthetic bacterial cell, known as *Mycoplasma laboratorium* in 2010. They synthesized an entire bacterial genome, inserted it into a bacterial cell, and

conditions for the rapid (14 day) assembly of the complete infectious genome of bacteriophage X174 (5386 bp), from a single pool of chemically synthesised oligonucleotides.

- In 2007, the successful transplantation of an M. mycoides capri LC GM12 genome into a *Mycoplasma capricolum* recipient cell was reported[626]. In this study, the recipient cell was transformed into the species of the implanted DNA.
- Other work in 2008[627] demonstrated the formation of s-triazines (alternative nucleobases), pyrimidines (including cytosine and uracil), and adenine from urea solutions subjected to freeze-thaw cycles under a reductive atmosphere, with spark discharges as an energy source. The explanation given for the unusual speed of these reactions at such a low temperature was eutectic freezing. As an ice crystal forms, it stays pure - only molecules of water join the growing crystal, while impurities like salt or cyanide are excluded. These impurities become crowded in microscopic pockets of liquid within the ice, and this crowding causes the molecules to collide more often[628].
- In 2008, the complete genome of *M. genitalium* was synthesised from scratch; starting with chemically synthesised oligonucleotides and stepwise recombination in vitro, and subsequently in Saccharomyces cerevisiae (yeast), using genetic manipulation tools to assemble the genome as a plasmid inside the yeast cell[629]. These methods enabled later the construction of JCVI-syn1.0, the first cell controlled by a synthetic genome[630].
- In 2008, Szostak's team found that protocells could survive being heated to 100°C, a temperature that would obliterate most modern cells. This supported the claim that protocells were the first form of life, which must have endured scalding heat from constant meteoric impacts. Although this was not a demonstration of creating life from scratch, it was a

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successfully transformed the cell into a new, self-replicating organism. This achievement marked a significant milestone in the field of synthetic biology. Craig Venter's work has had a profound impact on molecular biology, genetics, and biotechnology. He's been a driving force behind technological advancements that have not only expanded our understanding of life but have also paved the way for practical applications in medicine, industry, and environmental sustainability. Source: https://sciencejokes.quora.com/What-are-some-examples-of-scientists-who-had-brilliant-ideas-and-became-millionaires

625 https://www.jcvi.org/publications/generating-synthetic-genome-whole-genome-assembly-phix174-bacteriophage-synthetic

626 Lartigue C, Glass JI, Alperovich N, Pieper R, Parmar PP, Hutchison CA, Smith HO, Venter JC. Genome transplantation in bacteria: changing one species to another. Science. 2007;317:632–638. doi: 10.1126/science.1144622.

627 Cleaves, H. James; Chalmers, John H.; Lazcano, Antonio; et al. (April 2008). "A Reassessment of Prebiotic Organic Synthesis in Neutral Planetary Atmospheres." Origins of Life and Evolution of Biospheres. 38 (2): 105–115. *Bibcode:2008OLEB...38..105C*. *doi:10.1007/s11084-007-9120-3*. *PMID 18204914*. *S2CID 7731172*.

628 Chyba, Christopher F. (13 May 2005). "Rethinking Earth's Early Atmosphere." Science. 308 (5724): 962–963. *doi :10.1126/science.1113157*. *PMID 15890865*. *S2CID 93303848*

629 Gibson DG, Benders GA, Andrews-Pfannkoch C, Denisova EA, Baden-Tillson H, Zaveri J, Stockwell TB, Brownley A, Thomas DW, Algire MA, Merryman C, Young L, Noskov VN, Glass JI, Venter JC, Hutchison CA, Smith HO. Complete chemical synthesis, assembly, and cloning of a Mycoplasma genitalium genome. Science. 2008;319:1215–1220. doi: 10.1126/science.1151721.

630 NCBI GenBank: https://www.ncbi.nlm.nih.gov/nuccore/CP002027.1 Synthetic Mycoplasma mycoides JCVI-syn1.0 clone sMmYCp235-1, complete sequence. GenBank: CP002027.1

great success in demonstrating that one of the major components of the cell, RNA, could be chemically replicated[631].

- In 2004, Orel and colleagues demonstrated that freezing temperatures are advantageous for the synthesis of purines. This is due to the concentrating effect for key precursors such as hydrogen cyanide[632]. Research suggested that while adenine and guanine require freezing conditions for synthesis, cytosine and uracil may require boiling temperatures[633]. The notes of Stanley Miller and subsequent analyses of his ammonia and cyanide sample left in a freezer from 1972 to 1997, showed that 7 different amino acids and 11 types of nucleobases were formed[634,635].
- In 2009, Jack Szostak and his student Ting Zhu discovered a way to make protocells divide. Zhu fed the protocells with fatty acids, which made them grow bigger and change shape to elongated, rope-like strands. Once a protocell was long enough, a gentle shearing force was enough to make it shatter into dozens of small daughter protocells. Each daughter protocell contained RNA from the parent protocell, and hardly any of the RNA was lost. The protocells could perform this cycle repeatedly, with the daughter protocells growing and then dividing themselves.

While one aspect of the problem appeared to be solved, the protocells still lacked sufficient RNA activity and were not capable of self-replication. Researchers revisited the work of Leslie Orgel, who had extensive experience with RNA and had apparently discovered a method for genes to copy themselves. They discovered that under certain conditions, RNA strands could replicate without any assistance from enzymes. Orgel's method involved taking a single strand of RNA and a pool of loose nucleotides, and using those nucleotides to assemble a second strand of RNA that complemented the first one. This could have been how early life copied its genes on early Earth.

Szostak and his student Katarzyna Adamala applied Orgel's method to protocells. They reconstructed the genes while taking in useful molecules from their surroundings. Initially they encountered issues with excess magnesium, but this was resolved by adding citric acid which

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631 https://chemistry.uchicago.edu/news/szostak-lab-uncovers-new-mechanisms-of-rna-stability-and-interaction-paving-the-way-for-origins

632 Orgel, Leslie E. (August 2004). "Prebiotic Adenine Revisited: Eutectics and Photochemistry." Origins of Life and Evolution of Biospheres. 34 (4): 361–369. *Bibcode*:*2004OLEB...34..361O*. *doi*:*10.1023/B:ORIG.0000029882.52156.c2*. *PMID 15279171*. *S2CID 4998122*.

633 Robertson, Michael P.; Miller, Stanley L. (29 June 1995). "An efficient prebiotic synthesis of cytosine and uracil." Nature. 375 (6534): 772–774. *Bibcode*: 1995 Nature.375..*772R* . *doi*:*10.1038/375772a0*. *PMID 7596408*. *S2CID 4351012*.

634 Levy, Matthew; Miller, Stanley L.; Brinton, Karen; *Bada, Jeffrey L.* (June 2000). "Prebiotic Synthesis of Adenine and Amino Acids Under Europa-like Conditions." *Icarus*. 145 (2): 609–613. *Bibcode*: *2000Icar..145..609L* . *doi*:*10.1006/icar.2000.6365*. *PMID 11543508*.

635 Fox, Douglas (February 2008). *"Did Life Evolve in Ice?"*. *Discover*.

latched onto the magnesium, protecting the protocells and enabling template copying to proceed. In just over a decade of research, Szostak's team accomplished something remarkable: they developed protocells capable of growth, division, and competition, with RNA replication occurring inside them. These protocells exhibited life-like characteristics and remarkable resilience, a significant milestone in scientific advancement.

- In 2010, the work at JVCI (over several years) was successful in creating the first synthetic bacterial cell known as *Mycoplasma mycoides*, or JCVI-syn1.0. In an online publication in *Science* magazine on May 20, 2010, the JCVI researchers outlined the steps to synthesise this genome. The 1.08 million base pair synthetic M. mycoides genome was the largest chemically defined structure ever constructed in a laboratory at that time.

This work proved that genomes could be designed in a computer, chemically made in a laboratory, and transplanted into a recipient cell, so that a new self-replicating cell controlled only by the synthetic genome could be produced[636]. The resulting bacterium could be regarded as the first truly synthetic organism.

The Venter Team had previously demonstrated their ability to synthesise a bacterial genome and separately transplant the genome of one bacterium into another. This time, their goal was to synthesise the genome of *Mycoplasma mycoides*, and transplant it into another bacterium, *M. capricolum*, and observe how the artificial genes activated the recipient cell to produce M. mycoides proteins, known as biochemical products.

On May 21, 2010, Leigh Dayton[637], a news.com.au reporter explained the method used by Dr Venter and his team to create the first artificial life:

1. Decode DNA from a bacterium (single-celled organism), in this case *Mycoplasma mycoides*

2. Synthetically create the DNA of the bacterium in the laboratory, and add a watermark to distinguish it from real DNA

3. Transplant the artificial DNA into a living bacterium (in this case *Mycoplasma capricolum*), with its own authentic DNA

4. Allow the bacterium, which now contains both artificial and authentic DNA, to divide and create daughter bacteria, some of which contains artificial DNA and some which contains authentic DNA

[636] https://newatlas.com/first-synthetic-organism-created/15165/?itm_source=newatlas&itm_medium=article-body

[637] https://www.news.com.au/technology/science/geneticist-craig-venter-creates-first-artificial-life/news-story/779113af77fff4c2eb75dd618e6eaaa4

5. Add an antibiotic which kills the bacteria with authentic DNA, but not the bacteria with artificial DNA

6. Allow the artificial bacteria to produce proteins

RESULT: The synthetic genome's DNA was transcribed into messenger RNA, which was then translated into new proteins. The artificial DNA successfully produced proteins. Within two days, viable *M. mycoides* cells containing only synthetic DNA were clearly visible on Petri dishes containing bacterial growth medium from the original bacterium, *Mycoplasma mycoides*, marking the world's first artificial cell.

- In 2012 and the following years, the ENCODE project started. This was the journey to understand the makeup of humans. Scientists aim to unravel the secrets of how the genome operates, and demonstrate that at least 80% of the genome is biologically active.
- In 2012, chemists from the University of California, San Diego (UCSD) and Harvard University created artificial self-assembling cell membranes. They used a watery emulsion of an oil and detergent that is, on its own, very stable. However when copper ions are added, durable vesicles and tubules begin to bud off the oil droplets[638]. After 24 hours, the oil droplets were "consumed" by the self-assembling membranes.
- In 2014, other approaches such as the metabolism-first hypothesis aimed to understand how catalysis in chemical systems on early Earth might have provided the precursor molecules necessary for self-replication[639].
- By 2015, scientists could read the human genome at an unprecedented level of detail, understanding the complex instruction set which ultimately influences a wide range of human biology. Humans were now equipped with sufficient knowledge to tackle the task of synthesising life in a laboratory.
- In March of 2015, NASA scientists reported that for the first time, complex DNA and RNA organic compounds of life (including uracil, cytosine and thymine) were formed in the laboratory under the conditions present in outer space. They used starting chemicals such as pyrimidine, which is found in meteorites. Pyrimidine, like polycyclic aromatic hydrocarbons, is

[638] Darren Quick, 2012. Synthetic cell membrane marks another step towards creation of fully artificial life forms. https://newatlas.com/synthetic-cell-membrane-created/21263/ Itay Budin and Neal K. Devaraj, December 29, 2011. Membrane Assembly Driven by a Biomimetic Coupling Reaction J. Am. Chem. Soc. 2012, 134, 2, 751–753 https://doi.org/10.1021/ja2076873

[639] Keller, Markus A.; Turchyn, Alexandra V.; Ralser, Markus (25 March 2014). *"Non-enzymatic glycolysis and pentose phosphate pathway-like reactions in a plausible Archean ocean"*. *Molecular Systems Biology*. 10 (725): 725. *doi :10.1002/msb.20145228*. *PMC 4023395*. *PMID 24771084*

the most carbon-rich chemical found in the universe, and may have been formed in red giant stars, or in interstellar dust and ionised gas clouds[640].

- In 2015, a group of Czech scientists reported that all four RNA bases may be synthesised from formamide during high-energy and high-density events like extraterrestrial impacts[641].
- In 2016, Breuer et al.[642] applied a successful bottom-up approach to design a minimal genome and create a living cell controlled by it. They began with the gene sequence from the ruminant pathogen *Mycoplasma mycoides capri* serovar LC GM12, designing and constructing a minimal genome comprising of 473 genes (438 protein-coding genes and 35 RNA genes) (op.cit.). This achievement was the culmination of a series of breakthroughs in synthetic biology, leading to the creation of JCVI-syn1.0 through transplantation into *M. capricolum* recipient cells(op.cit.). Further design, assembly and growth efforts yielded JCVI-syn3.0[643], which retains all essential and quasi-essential genes necessary for growth, while eliminating individually non-essential genes to the greatest extent possible without causing synthetic lethality or significant growth disadvantages from simultaneous knockouts[644]. A simplified near-minimal bacterial cell can be synthesised from a synthetic genome, exemplified by strain JCVI-syn3A, whose complete genome sequence is available via the NCBI link shown in the footnote[645]. For a detailed technical comparison of JVCI-Syn-1 and JVCI-Syn-3 refer to the footnote[646].

- In 2021, Cay Leytham-Powell reported[647] that University of Colorado scientists had constructed the first synthetic DNA-like polymer. This involved intertwining pairs of helical strands to form a double helix through a network of hydrogen-bonding interactions, and applying dynamic covalent chemistry. Double helical covalent polymers, which are spiral arrangements of nature's building

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640 Marlaire, Ruth, ed. (3 March 2015). "NASA Ames Reproduces the Building Blocks of Life in Laboratory". Ames Research Center. Moffett Field, CA: NASA.

641 Ferus, Martin; Nesvorný, David; Šponer, Jiří; Kubelík, Petr; Michalčíková, Regina; Shestivská, Violetta; Šponer, Judit E.; Civiš, Svatopluk (2015). "High-energy chemistry of formamide: A unified mechanism of nucleobase formation". Proc. Natl. Acad. Sci. U.S.A. 112 (3): 657–662. Bibcode: 2015PNAS..112..657F. doi:10.1073/pnas.1412072111. PMC 4311869. PMID 25489115.

642 Breuer, Marian; Earnest, Tyler M.; Merryman, Chuck; Wise, Kim S.; Sun, Lijie; Lynott, Michaela R.; Hutchison, Clyde A.; Smith, Hamilton O.; Lapek, John D.; Gonzalez, David J.; De Crécy-Lagard, Valérie; Haas, Drago; Hanson, Andrew D.; Labhsetwar, Piyush; Glass, John I.; Luthey-Schulten, Zaida (2019). "Essential metabolism for a minimal cell". Published online: eLife. 8. doi:10.7554/eLife.36842. PMC 6609329. PMID 30657448.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6609329/#idm140351095225776aff-info

643 Hutchison CA, Chuang RY, Noskov VN, Assad-Garcia N, Deerinck TJ, Ellisman MH, Gill J, Kannan K, Karas BJ, Ma L, Pelletier JF, Qi ZQ, Richter RA, Strychalski EA, Sun L, Suzuki Y, Tsvetanova B, Wise KS, Smith HO, Glass JI, Merryman C, Gibson DG, Venter JC. Design and synthesis of a minimal bacterial genome. Science. 2016a;351:aad6253. doi: 10.1126/science.aad6253.

644 Breuer, M., et al., (2019). "Essential metabolism for a minimal cell". Published online: eLife. 8. doi:10.7554/eLife.36842. PMC 6609329. PMID 30657448. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6609329/

645 Glass JI. 2017. Synthetic bacterium JCVI-Syn3.0 strain 6d, complete genome. NCBI Nucleotide. CP016816.2

646 Breuer, M., et al., (2019). "Essential metabolism for a minimal cell". Published online: eLife. 8. doi:10.7554/eLife.36842. PMC 6609329. PMID 30657448. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6609329/

647 Yiming Hu et al. Single crystals of mechanically entwined helical covalent polymers, Nature Chemistry (2021). DOI: 10.1038/s41557-021-00686-2. May 17, 2021. https://phys.org/news/2021-05-scientists-first-ever-synthetic-dna-like-polymer.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

blocks, are fundamental to life itself. Despite decades of research, scientists had never succeeded in synthesising them before until 2021.

The literature review[648] showcases the amazing journey of scientists worldwide to shed light on where and how we came to exist. Over the past 200 years, they have made tremendous progress, including the creation of the first self-replicating synthetic bacterial cell. However, this achievement did not create life from scratch. Instead, it involved generating new life from existing life using synthetic DNA and reprogramming cells to produce new cells specified by the synthetic DNA. As Shelley Saxena explained[649] *"If you just connect some hardware and insert a Windows Operating System Compact Disc (OS CD), would you get a working computer? No, that hardware needs BIOS (Basic Input/Output System), a set of instructions in firmware that control input and output operations to boot up Windows OS CD and install the Operating System to give us a working computer."* In her view, the research so far has identified most of the chemical reactions fundamental to a living cell's function, but the biological BIOS required to start basic processes and complex operations like survival and DNA based replication remain elusive. *"When we create a new living cell from an existing living/semi-living cell, we automatically get the BIOS. But to create life from scratch, it is essential to figure out what this BIOS consists of [(op. cit)].*

It has become clear that creating a living cell is more complicated than anyone had thought. Living cells were not just bags of chemicals, they were intricate little machines, some factories, some information storage and retrieval centres. We have also realised there are new challenges waiting just around the corner. Putting the ethical, social, and political repercussions aside for the time being, assuming that we have managed to make a real synthetic cell from scratch - how will we bind these cells together to create tissues, fully functional organelles, and then a synthetic living organism?

We should be upfront and state that despite knowing from the Big Bang calendar approximately when life first appeared on Earth, scientists still struggle to answer how life on Earth came to existence[650]. Some progress has been made, but we still do not know exactly how organic molecules become a living cell. We still lack a complete understanding of how chemical signals induce the

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[648] Mainly obtained from Stephanie Pappas (2013) Unraveling the Human Genome: 6 Molecular Milestones. https://www.livescience.com/26505-human-genome-milestones.html https://en.wikipedia.org/wiki/Artificial_cell and How did life get started? By Michael Marshall, 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

[649] https://saxenas.wordpress.com/2015/08/23/why-cant-we-make-living-cells-from-scratch/

[650] https://en.wikipedia.org/wiki/Abiogenesis

formation of living tissues and organs, with their unique shapes and material properties[651]. While scientists' accomplishments over the last 100 years did not create an artificial living organism, what they did was still extremely impressive considering that only a century ago almost everyone believed that creation was entirely "god's handiwork", and that any alternative explanation was inconceivable[652]. Subsequent attempts to create artificial life have focused on reverse-engineering natural cells and modifying them to meet specific needs using techniques such as gene editing, synthetic DNA assembly, and metabolic engineering.

One of the most notable achievements in this field was the creation of synthetic cells from scratch, which involved constructing the cell membrane and inserting synthetic DNA. In 2010, scientists at the J. Craig Venter Institute reported creating the first synthetic cell with a genome made entirely from scratch. However, this synthetic cell required a pre-existing natural cell membrane to function.

The Jack W. Szostak Laboratory at the University of Chicago, U.S.A., is entirely focused on investigating the chemical and physical processes that facilitated the transition from chemical evolution to biological evolution on early Earth. The Szostak Laboratory investigates the construction of a synthetic cellular system that undergoes Darwinian evolution. Professor Szostak and his research team have made significant progress, as mentioned in this section. This was announced discoveries in June 21, 2024 as "Szostak Lab uncovers new mechanisms of RNA stability and interaction, paving the way for origins of life"[653]. Szostak was earlier awarded the 2009 Nobel Prize for the discovery of how chromosomes are protected by telomeres.

These attempts to create living cells from inanimate precursors in the laboratory are still in their infancy, and much research is needed before we can truly create a living, self-sustaining synthetic organism.

Will it ever be possible to re-create artificial life, even a simple cell, by the end of the 21st century? The answer is most likely yes, considering human ingenuity and perseverance; however, this is a significant expectation. The living beings we see around us are the result of millions, if not billions, of years of evolution - not just a few hundred years of human effort. My personal belief is that with

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651 Tadanori Mammoto and Donald E. Ingber, 2010. Mechanical control of tissue and organ. Development 2010 137: 1407-1420; doi: 10.1242/dev.024166

652 Michael Marshall, 31 October 2016. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began

653 https://chemistry.uchicago.edu/news/szostak-lab-uncovers-new-mechanisms-of-rna-stability-and-interaction-paving-the-way-for-origins

advancements in artificial intelligence based modelling (for example see the footnote)[654], and the application of concepts like self-assembly, self-organisation, and fractal theory, combined with miniaturisation technologies, biologists will eventually succeed if they team up. This will require a multidisciplinary, hopefully international, team of creative minds.

[654] Subham Choudhury et al, (2024. Generative machine learning produces kinetic models that accurately characterize intracellular metabolic states, *Nature Catalysis*. DOI: 10.1038/s41929-024-01220-6. AND https://phys.org/news/2024-08-ai-tool-cell-metabolism-precision.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

CHAPTER IX. THE TREE OF LIFE - THE RISE OF HUMANS

The word “alive” refers to the state of having life, the opposite of being dead. The word “dead” refers to something which is deprived of life, or something is not alive. An organism is considered alive if it is composed of cells capable of carrying out essential functions such as metabolising food to produce energy and sustain its existence, and reproducing to ensure the continuation of its species. Living organisms did not appear overnight (or in six days). According to scientists, life on Earth emerged gradually and diversified from a single source called LUCA (Last Universal Common Ancestor) over a period of 3.5 billion years. Keith Cooper of NASA (2018)[655] estimated LUCA to be approximately 4 billion years old, placing it within the Hadean Eon in the geologic time scale. This diversification gave rise to the Tree of Life, a lineage chart that includes all living beings, including humans.

As discussed earlier, we are the products of our mothers and fathers, who are themselves the products of many generations of their ancestors. It is very likely that my earliest ancestor was somehow related to your earliest ancestor. Following this logic, all human beings, Homo sapiens, are genetically connected through a common ancestor. Similarly, every species is the result of many generations of their parents and grand-grandparents, tracing back to their own single common ancestor. This lineage extends all the way back to the LUCA.

IX.1. WHAT IS LUCA? - THE MOTHER OF ALL LIVING THINGS

LUCA is the common ancestor of all living beings. Charles Darwin proposed the existence of an evolutionary starting point and a primordial organism from which all modern life descended. This idea initiated the search for the last universal common ancestor. Research[656] suggests that LUCA likely evolved from organic molecules, consisting of several inorganic atoms of carbon, hydrogen, oxygen, nitrogen, and trace elements. Once the first cell formed, it adapted to its environment, learned to multiply, and passed on its characteristics to subsequent cells. Therefore, LUCA was alive. Over time, advantageous traits accumulated, leading to more complex forms of life - first as multicellular organisms and eventually encompassing all other living beings, including us.This process took between 3 to 4 billion years on Earth.

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[655] Keith Cooper of NASA (2018). Looking for LUCA, the last universal common ancestor. https://phys.org/news/2018-12-luca-universal-common-ancestor.html

[656] Fox, G. E. *et al.* The phylogeny of prokaryotes. *Science* 209, 457–463 (1980). Arndt, N. & Nisbet, E. Processes on the young Earth and the habitats of early life. *Annu. Rev. Earth Planet Sci.* 40, 521–549 (2012).
Woese, C. The universal ancestor. *Proc. Natl Acad. Sci. USA* 95, 6854–6859 (1998).

While there is no specific fossil record of LUCA, evidence supporting the concept that we are all connected to a single origin comes from comparing the genomes of all modern organisms. For example, a 2016 study[657] identified a set of 355 genes most likely to have been present in LUCA. Researchers from Düsseldorf, Germany[658], analysed DNA databases and examined the genome sequences of around 2,000 modern microbes. Out of six million total genes, they found 355 gene families common among these microbes. William Martin, an evolutionary biologist at Heinrich Heine University in Düsseldorf, Germany, established that LUCA's genes have survived and are still visible in the genes of modern organisms. The study of these 355 genes indicates that LUCA lived in an environment with no oxygen.

According to Keith Cooper of NASA (2018),[659] LUCA lived in iron and sulphur-rich hydrothermal vents, an environment without sunlight and oxygen. These microbes feed on carbon dioxide, hydrogen, and nitrogen-based chemical substances such as methane, ammonia, and hydrogen sulphide. Their habitat was hot, around 100°C, indicating that LUCA's genes were likely those of an extremophile, capable of tolerating such temperatures[660]. This claim was based on findings of similar organisms in the 1970s in modern hydrothermal vents, particularly in areas where vents emitted toxic plumes of sulphide gases and deposited metal sulphides (see Chapter VIII).

The lithotrophic bacteria (or lithotrophs) use inorganic compounds as electron donors to conserve energy for growth. They were widespread among bacterial organisms before the process of photosynthesis emerged. It has been proposed[661] that the earliest forms of life on Earth used lithotrophic metabolism, and that photosynthesis was a later development in the early bacterial progenitors[662].

In science, alternative prepositions often exist. One major alternative view to the origin of life is Darwin's "warm little ponds" hypothesis, which suggests that life began on land in pools of water (lagoons), rather than deep in the ocean. The picture may not be as simple as presented here; multiple mechanisms might have operated in tandem or in different environments. For instance, *Halobacterium*, a photosynthetic archaeon, has a completely different type of photosynthesis. It

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657 https://en.wikipedia.org/wiki/Tree_of_life_%28biology%29

658 Weiss, M., Sousa, F., Mrnjavac, N. et al. The physiology and habitat of the last universal common ancestor. Nat Microbiology 1, 16116 (2016). https://doi.org/10.1038/nmicrobiol.2016.116. https://www.nature.com/articles/nmicrobiol2016116

659 Keith Cooper of NASA (2018). Looking for LUCA, the last universal common ancestor. https://phys.org/news/2018-12-luca-universal-common-ancestor.html

660 Nicholas Wade, 2007, "Before the Dawn- Recovering the Lost History of our Ancestors" Penguin Group, ISBN 978-0-14-303832-0

661 https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/evolutionary-origin-bacteria-and-viruses

662 "Progenitor" means the earliest recorded ancestor of a consanguineous (blood related) family group of descendants.

does not use chlorophyll in large protein complexes to activate an electron, as seen in plants and bacteria. Instead, they use a single protein, bacteriorhodopsin, where sunlight is absorbed by a form of vitamin A to activate a proton (hydrogen ion) [663].

However, it is certain that once the very primitive living cell was formed, the foundation of the Tree of Life was established.

Tree of Life diagrams show that life as we currently know it is divided into three domains: Archaea, Bacteria and Eukarya, and six kingdoms. Two of these kingdoms, Eubacteria and Archaebacteria, consist of single-celled organisms without a distinct nucleus. The other four kingdoms within the Eukarya domain are animalia, plantae, fungi, and protists; all of which have distinct nuclei. These life forms all evolved from a single-celled ancestor, LUCA, that lived about 4 billion years ago when Earth was in its primordial stage[664].

The Archaea and some Bacteria domains are believed to have emerged in high-temperature environments[665] making them hyperthermophile organisms[666]. Organisms in the Eukarya domain were largely mesophiles, indicating that the emergence of these organisms occurred at lower temperatures in organic-rich environments, such as lakes or lagoons, near active volcanoes. Mesophile organisms, including certain bacteria and fungi, thrive at moderate temperatures ranging from about 25°C to 40°C.

IX.2. Tree of Life Diagrams - How Did This Diversity Come About?

The Tree of Life metaphor illustrates how all life on Earth descends from a common ancestor, and shows how species have branched out and evolved over time. It is organised like any other family tree. The trunk represents the original single-celled organism which gave rise to all life on Earth. The branches represent various groups of organisms which evolved from that common ancestor.

The main branches of the Tree of Life are the three domains of life: Archaea, Bacteria, and Eukarya. Archaea and Bacteria are often grouped together as prokaryotes. These are unicellular organisms which lack a true nucleus or other membrane-bound organelles. Eukarya, on the other hand,

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[663] https://en.wikipedia.org/wiki/Retinal ; Retinal is a polyene chromophore, bound to proteins called opsins, and is the chemical basis of animal vision. Retinal allows certain microorganisms to convert light to metabolic energy.

[664] https://www.smithsonianmag.com/smart-news/behold-luca-last-universal-common-ancestor-life-earth-180959915/

[665] https://pubmed.ncbi.nlm.nih.gov/14745541/ Massimo Di Giulio 12003. The universal ancestor and the ancestor of bacteria were hyperthermophiles J Mol Evol; 57(6):721-30. PMID: 14745541, doi: 10.1007/s00239-003-2522-6.
https://pubmed.ncbi.nlm.nih.gov/14745541/ Di Giulio M. J Theor Biol. 2003. The universal ancestor was a thermophile or a hyperthermophile: tests and further evidence. J Theor Biol 2003 Apr 7;221(3):425-36. doi: 10.1006/jtbi.2003.3197. PMID: 12642117

[666] An optimal temperature for the existence of hyperthermophiles is above 80 °C; https://en.wikipedia.org/wiki/Hyperthermophile

includes all organisms with cells which have a true nucleus and other organelles, such as plants, animals, fungi, and protists.

Within each domain there are multiple branches which represent different groups of organisms, such as phyla, classes, and orders. For example, within the Eukarya domain there are several major branches including animals, plants, fungi, and protists. Each of these branches are then further divided into more specific groups.

The Tree of Life demonstrates how closely related different groups of organisms are. For example, humans share a more recent common ancestor with chimpanzees and other great apes than we do with other mammals, such as mice or dogs. Likewise, plants are more closely related to fungi than they are to animals.

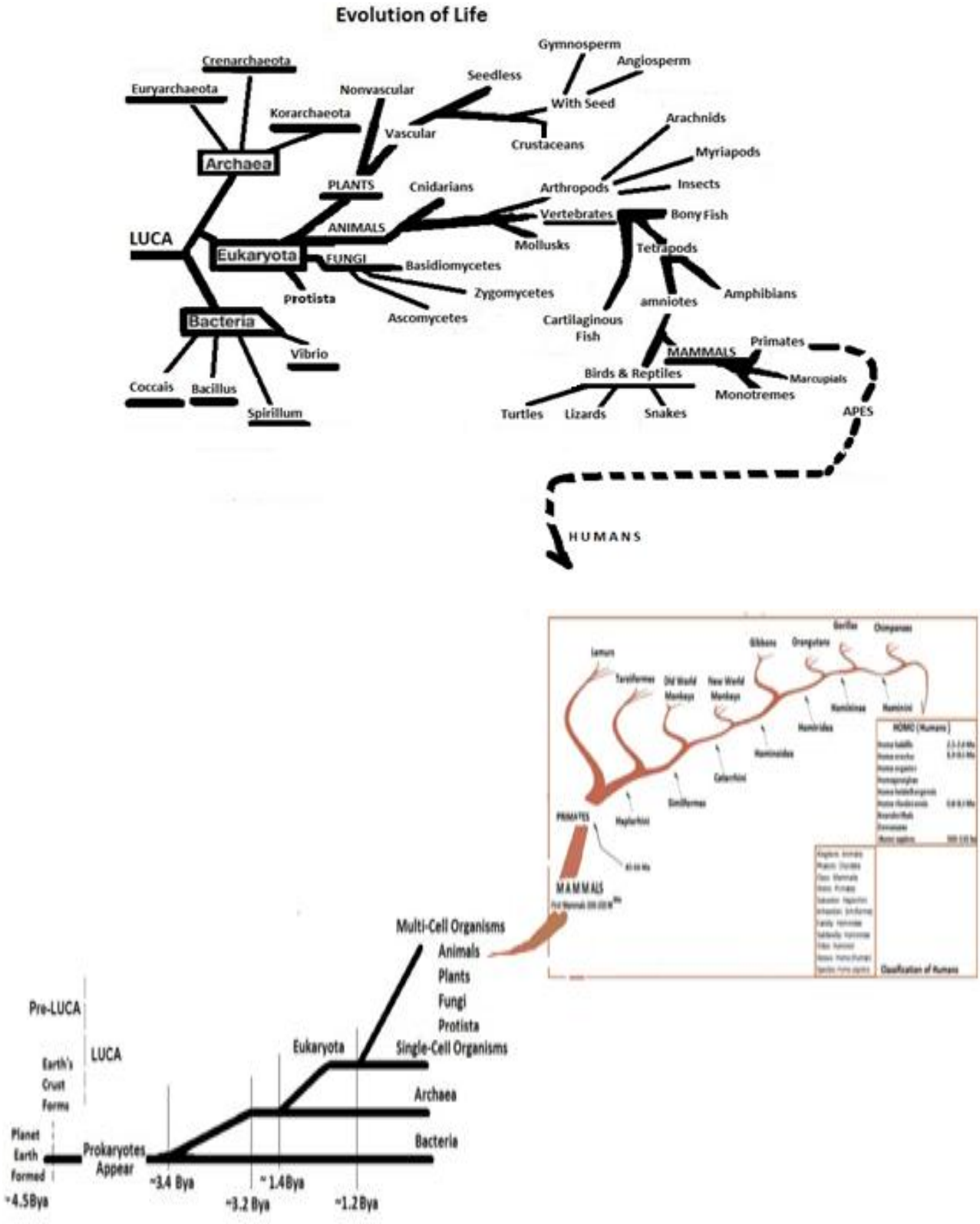
There are two leading versions of the Tree of Life diagrams: the three-domain, and the two-domain. The difference between these diagrams is whether Eukarya is a large offshoot, or the third branch of the diagram. The two-domain view suggests that eukaryotes are not one of the main branches of the tree, but merely a large offshoot from the other two domains. The classical version is the three-domain diagram.

THREE-DOMAIN DIAGRAM

The three-domain diagram of the Tree of Life suggests that the tree consists of three main domains: Bacteria, Archaea and Eukarya, with LUCA at the base (see figure below). The first two domains are the prokaryotes, which are single cell organisms lacking a nucleus. They are differentiated from one another by subtle chemical and metabolic differences.

The third domain, Eukarya, are multicellular organisms with membrane-encased cells incorporating a nucleus containing genetic code, as well as the mitochondria powering the cell's metabolism. The members of this domain are complex life forms. Because of these differences, the Eukarya are considered to have their own domain as an offshoot from Archaea.

There are various reasons for the branches in each domain including natural selection (or natural elimination), changes in environmental conditions, and mutations. Organisms which adapt best to their environment are the ones which survive and successfully propagate, producing many descendants. Nature seems to eliminate the most poorly suited individuals, so that most of the time, only populations well suited to their environments remain in existence.



The three-domain (Eukaryote, Bacteria and Archaea) model of Tree of Life shows the rise of all living beings from LUCA. The branching of animals, including humans, in evolutionary development is also shown. This figure shows that the ancestry of multi-cell organisms goes back more than 3.5 billion to 4.0 billion years - nearly the beginning of life on Earth.

Every species is constantly evolving, adapting new physical traits and behaviours on top of those inherited from their earlier ancestors[667]. This inheritance takes place through reproduction, which involves many diverse mechanisms. The human reproduction mechanism involves the male passing his sperm cells to the female's egg. The egg and sperm cells contain DNA, which itself contains a set of encoded instructions needed to make an offspring.

Living beings must adapt to their surroundings in order to survive and branch out. Occasionally, a genetic variation or a change in environmental conditions can give one member of a species an edge. When that individual passes the beneficial gene on to its descendants, the trait is passed on to greater and greater numbers of offspring. More individuals with this new, beneficial trait survive and go on to continue passing the gene on to their descendants.

If many beneficial traits arise over time, a new species can evolve. The new species will be better equipped to meet the challenges of its environment. Genetic variations are often the result of a change in environmental conditions, random mutations, and copying errors in DNA[668]. These externally imposed factors may result in the creation of a population which is better suited to the environment than before. For example, the flippers of fish used for swimming may be modified for use as legs on land as in the case of penguins and seals.

The mutations, viruses and copying errors in cells could cause detriment to the species, by decimating the numbers of the population. Some events can even cause the sudden disappearance (or appearance) of entire species. For example, the impact of a meteorite, toxic gases in the air from extensive volcanic activity, a prolonged ice age or drought, a rise in ocean temperature, or an increase in acidity of the ocean water can remove or add new kingdoms, phylum, classes, orders, families, and species to the Tree of Life.

Viruses[669] play a very significant role in the evolution of life. Since viruses can acquire genes from their hosts and paste these genes into new hosts, this can potentially steer their hosts onto new evolutionary paths[670]. In some cases, this occurs to the demise (death) of the host.

The Tree of Life Diagram[671,672] excludes biological evolution which took place before the appearance of bacteria. In this period, the construction of inanimate organic molecules occurred,

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667 https://www.amnh.org/exhibitions/darwin/evolution-today/natural-selection-vista

668 https://humanorigins.si.edu/education/frequently-asked-questions

669 Viruses are parasitic organisms. They are not capable of reproducing themselves and for their reproduction they need a host.

670 Zimmer C (May 2006). "Did DNA come from viruses?." Science. 312 (5775): 870–2. doi:10.1126/science.312.5775.870. PMID 16690855. S2CID 39984425.

671 https://en.wikipedia.org/wiki/Abiogenesis#Phylogeny_and_LUCA

672 https://www.nature.com/articles/s41579-020-0408-x

such as RNA, DNA, and virus-like cells including viroids, virusoids, and prions[673]. The period of time before the appearance of LUCA is referred to as pre-LUCA time. During pre-LUCA time, the essential components of LUCA were made. This is discussed further below.

Bacteria and the Archaea are distinguished from each other by the presence of the molecule *peptidoglycan.* This is a polymer consisting of polysaccharide and peptide chains in the cell walls of most Bacteria, which is not present in Archaea[674] . Recent evidence (op. cit.) indicates that Archaea and Eukarya are more closely related to each other than either is to Bacteria. This is based on analyses of the nucleotide sequences of rRNA (ribosomal RNA). All organisms tested from Eukarya and Archaea had a particular nucleotide sequence in common, but none of those tested from Bacteria had this nucleotide sequence (op. cit.).

If all living organisms descended from a common ancestor, then they must have some genes in common. We can take any two species on the Tree of Life and find out which genes were present in the common ancestor of the two species, by looking for the genes that they still share to this day. When two species are closely related (close together on the Tree of Life), we can observe that much of their genome is the same. This has been proved by genome studies conducted on a variety of species during the last few decades. For example, the lineage of humans in figure below shows that humans (Homo sapiens) belong to Class Mammalia and the Family of Hominidae, and are genetically related to chimpanzees, as was proven from a comparison of their genomes.

It appears that humans are genetically closest to chimpanzees and bonobos (*Pan paniscus*) - a smaller relative of chimps - sharing almost 99% of genes, as reported in the Journal *Science* in 2012[675]. Gorillas are next, sharing 98% of genes with humans. Genome matching studies have shown that humans share DNA not only with common chimpanzees (*Pan troglodytes*), but with a variety of other animals cows, cats, dogs, horses, and even with plants[676].

These genome comparisons also demonstrate that the structure of the DNA molecule: the double helix shape and the mode proteins are coded in the same way from organisms ranging from bacteria to yeasts, to plants and animals. This suggests the existence of a common ancestor, and therefore every living being arose from the same source: LUCA.

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673 Staff (13 August 2019). "Difference among virus, virion, viroid, virusoid and prion". Microbiology Easy Notes. Retrieved 18 May 2020.

674 Matej Vesteg and Juraj Krajčovič (2011). The falsifiability of the models for the origin of eukaryotes. Curr Genet, 57(6):367-90.PMID: 22008946, DOI: 10.1007/s00294-011-0357-z. Epub 2011 Oct 19.

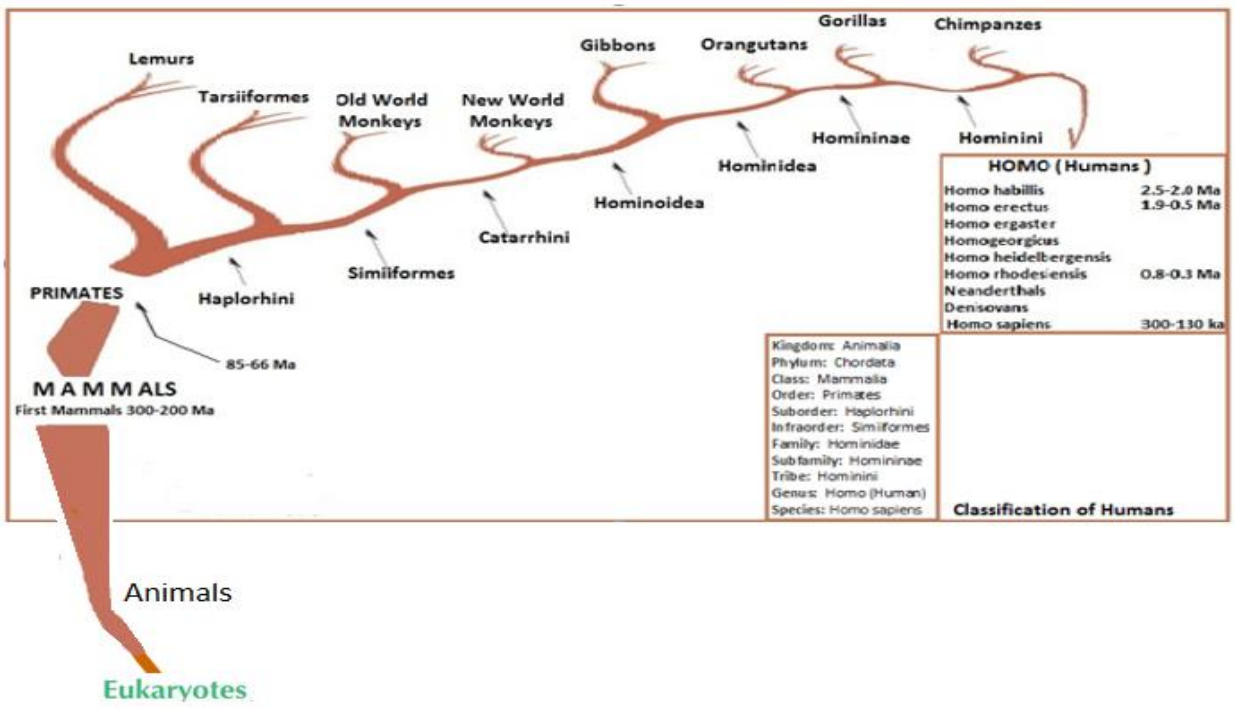
675 https://www.science.org/content/article/bonobos-join-chimps-closest-human-relatives-rev2

676 https://www.factchecker.in/humans-cows-share-80-genes-as-home-minister-said-but-mice-dogs-apes-are-closer/

TWO-DOMAIN DIAGRAM

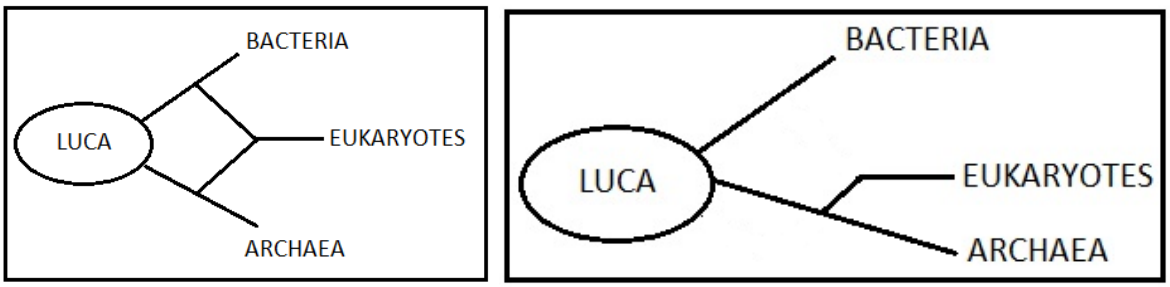
The two-domain diagram of the Tree of Life (see figure below) was proposed by evolutionary biologists Jim Lake at UCLA in 1984, and later by Martin Embley and William Martin at the Heinrich Heine University in Düsseldorf, Germany.

William Martin and six of his Düsseldorf colleagues, Madeline Weiss et al., published a 2016 paper in the journal *Nature Microbiology* describing this new perspective on LUCA and the two-domain tree with phylogenetics[677]. Their hypothesis suggests that the first eukaryotes were added to the Tree of Life later through the process of endosymbiosis, where an archaeal host merged with a symbiont, in this case bacteria. Endosymbiosis refers to one organism living completely inside another organism. The endosymbiotic theory explains how organelles inside eukaryotic cells are descended from ancient unicellular prokaryotic organisms. According to the two-domain view, eukaryotes are not one of the main branches of the Tree of Life, but merely a large offshoot, as shown in figure below.



Close-Up : Family lineage of humans.

677 HTTPS://PHYS.ORG/NEWS/2018-12-LUCA-UNIVERSAL-COMMON-ANCESTOR.HTML



The three-domain (left) versus two-domain (right) Tree of Life, showing the evolution of Eukaryotes.

Further information can be found at the sites shown in the footnote which provides in depth coverage of the origin of LUCA[678].

IX.3. PRE-LUCA TIME

LUCA did not come out of nowhere. In biological evolution, there is a pre-LUCA stage which should also be incorporated into the Tree of Life. The pre-LUCA stage is the phase in which the components of living cells were made from inanimate matter, including proteins, RNA, DNA and viruses. Although these are not components of life, they are essential in building the LUCA.

These proteins, RNA and DNA were made from inanimate molecules of deep-sea hydrothermal vents, or formed as free-floating pieces of nucleic acids in the "primordial soup" in a little pond on the surface of the earth. A recent study[679] suggests that ribonucleotides, the building blocks of RNA, could be synthesised in a primordial soup environment.

Life on Earth could have begun with a simple RNA molecule, which could copy itself without help from any other molecules. The general view is that RNA existed on Earth before the rise of modern cells, and before the evolution of DNA. According to this belief[680] which is referred to as the RNA World Hypothesis, RNA stored both genetic information and catalysed chemical reactions in primitive cells.

The RNA World hypothesis proposes that the first self-replicating molecules on Earth were RNA molecules, not DNA or proteins. This hypothesis was first proposed by Nobel Prize-winning

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[678] Madeline C. Weiss et al. The physiology and habitat of the last universal common ancestor, *Nature Microbiology* (2016). DOI: 10.1038/nmicrobiol.2016.116.
Laura Eme et al. Archaea and the origin of eukaryotes, *Nature Reviews Microbiology* (2017). DOI: 10.1038/nrmicro.2017.133
https://phys.org/news/2018-12-luca-universal-common-ancestor.html . And also
https://en.wikipedia.org/wiki/Endosymbiont

[679] Becker, S. *et al.* (2019) Unified prebiotically plausible synthesis of pyrimidine and purine RNA ribonucleotides. Science 366, 76.

[680] https://en.wikipedia.org/wiki/RNA_world

scientist Walter Gilbert in 1986. According to this theory, RNA was the first macromolecule to arise spontaneously from non-living matter.

The RNA World hypothesis suggests that RNA molecules were able to self-replicate, allowing them to reproduce and develop properties of life. RNA is capable of carrying genetic information and can also act as an enzyme, catalysing chemical reactions. This versatility of RNA makes it a suitable candidate for the role of the first molecule to support life.

The hypothesis suggests that RNA molecules could have formed in a primordial "soup," a primitive environment where organic molecules collided and reacted with each other. Some scientists suggest that RNA was formed on the surface of clay minerals, which may have acted as a scaffold for the formation of RNA molecules.

The RNA World hypothesis also suggests that RNA molecules existed before DNA and proteins. RNA may have provided the template for DNA, which eventually became the primary genetic material for all living organisms. Proteins, on the other hand, are composed of amino acids, which are coded by the genetic information stored in DNA.

The RNA World hypothesis is supported by various pieces of evidence. These include the discovery of ribosomes - RNA molecules which can act as enzymes. Ribosomes are capable of replicating themselves and carrying out chemical reactions. This supports the idea that RNA could have played a crucial role in the origin of life.

The RNA World hypothesis claims that self-replicating strands of RNA were the precursors to life and that some of these eventually developed into primitive cells[681]. According to this view, some RNA strands acted parasitically, like viruses, and that relationship was preserved when cells were developed. RNA-based viruses evolved into self-replicating cells which could produce their own proteins, able to absorb nutrients and replicate.

Only later in the process of biological evolution did DNA take over as the primary genetic material. Proteins also became the major catalyst and structural component of the first viruses, and then became fully developed self-replicating cells. This is because all viruses consist of a piece of nucleic acid, DNA or RNA, enclosed within a protein coat known as the capsid[682]. In coronaviruses, like COVID-19, the nucleic acid is a single-stranded RNA molecule (not a helix).

One of the mysteries relating to the origin of life is how droplets of RNA floating around in the primordial soup turned into living cells. A possible answer to this question came from Agrawal et al.

[681] John Steemson2010. http://www.askabiologist.org.uk/answers/viewtopic.php?id=4345
[682] https://www.ncbi.nlm.nih.gov/books/NBK26876/

(2024)[683]. They pointed out a critical step in the transition from lifeless molecules floating around (called coacervate tiny beads) to living beings. Coacervates are seen by biologists as candidates for the first protocells.

The coacervate is an aqueous phase rich in macromolecules such as synthetic polymers, protein, lipid, and nucleic acid. They could exchange molecules with one another, a key step in evolution; however, this exchange was happening too quickly, as detected by Prof. Jack Szostak in 2014. He showed that coacervate droplets tended to exchange their RNA content too rapidly. This means there would be no evolution because what is being created would be like identical clones.

A solution to this roadblock came from Agrawal et. al.[684]. They found that exposing coacervate droplets to rain (pure water) gives them a tough skin that restricts their ability to exchange RNA content quickly. Agrawal et. al., found that transferring coacervate droplets into distilled water increases the time scale of RNA exchange to several days, providing enough time for mutation, competition, and evolution. Otherwise, protocell populations would remain unstable, exchanging their genetic material with one another and becoming clones. Agrawal's work showed that if they stabilize against exchange and can store their genetic information well enough - at least for several days -mutations will have time to occur in their genetic sequences.

Viruses appear in almost every genome, ranging from bacteria to plants to animals. It is possible that without viruses, no diversity and possibly even no life form could have ever existed. A virus propagates by inserting small chunks of its genetic material into the DNA of other living things. The insertion of viral genetic material into the human genome has been occurring for millions of years. As a result of this ongoing process, the modern human genome contains close to 10% genetic material from viruses[685].

The importance of viruses to evolution is highlighted by Patrick Forterre (2006)[686] and Eugene V. Koonin (2006)[687]. These eminent biologists believe that the transition from RNA to DNA genomes occurred in the viral world. Koonin et al suggests the appearance of RNA viruses followed by retroid elements (or reverse transcriptase), DNA viruses, and the emergence of such genetic

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[683] https://phys.org/news/2024-08-life-rainwater-protocell-walls.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter#google_vignette

[684] Aman Agrawal et al, Did the exposure of coacervate droplets to rain make them the first stable protocells?, *Science Advances* (2024). DOI: 10.1126/sciadv.adn9657. www.science.org/doi/10.1126/sciadv.adn9657

[685] https://www.sciencedaily.com/releases/2016/11/161128151050.htm

[686] Forterre P (March 2006). "Three RNA cells for ribosomal lineages and three DNA viruses to replicate their genomes: a hypothesis for the origin of cellular domain". Proc. Natl. Acad. Sci. U.S.A. 103 (10): 3669–74. Bibcode:2006PNAS..103.3669F. doi :10.1073/pnas.0510333103. PMC 1450140. PMID 16505372.

[687] Koonin, E.V., Senkevich, T.G. & Dolja, V.V. The ancient Virus World and evolution of cells. *Biol Direct* 1, 29 (2006). https://doi.org/10.1186/1745-6150-1-29

diversity, predates the advent of fully fledged cells - therefore an extensive gene mixing took place before the rise of LUCA.

Patrick Forterre, an evolutionary biologist from the University of Paris-Sud in Orsay, France, believed that viruses are at the very heart of biological evolution, as they were instrumental in the transition from RNA to DNA, and the evolution of Bacteria, Archaea, and Eukaryota. He believes that the last universal common ancestor was an evolved RNA virus.

Cellular DNA and its replication machineries originated via transfers from DNA viruses to RNA cells. Some of these viruses evolved into DNA viruses, to protect their genes from attack by the process of viral infections. As a result, the three domains of life - Bacteria, Archaea, and Eukarya evolved[688].

Zimmer (2006)[689], in reference to Patrick Forterre said, *"DNA-based organisms are descended from simpler RNA-based organisms"*. Not only can RNA carry genetic information, but it is also capable of acting like an enzyme to carry out chemical reactions. Zimmer further said that *"The RNA viruses hijacked the RNA-based organisms, manipulating them to make their own new copies".*

The principal lineage of viruses and related genetic elements[690] emerged from the primordial pool of primitive genetic elements, which are the ancestors of both cellular and viral genes. Despite the numerous gene exchanges and acquisitions which occurred in the later stages of evolution, most, if not all, modern viruses and other genetic agents are believed to descend from elements within this primordial genetic pool.

Koonin and his colleagues[691] provided a coherent picture of the precellular evolution of viruses in primordial gene pools based on comparative-genomic data and the existing models of cellular evolution. These demonstrated that the RNA viruses, retroid elements, and several groups of DNA viruses, emerged within the primordial genetic pool where mixing and matching of diverse genetic elements were extensive (op.cit.).

Despite its initial appeal, the RNA World hypothesis is not without its critics. Some scientists argue that the dependence of RNA on protein enzymes and the problem of stability at high temperatures make it an unlikely candidate for the role of the first self-replicating molecule. Experimental

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688 https://en.wikipedia.org/wiki/RNA_world

689 *Zimmer C (May 2006). "Did DNA come from viruses?." Science. 312 (5775): 870–2. doi:10.1126/science.312.5775.870. PMID 16690855. S2CID 39984425.*

690 Selfish genetic elements are genetic segments that can enhance their own transmission at the expense of other genes in the genome, even if this has no positive or a net negative effect on organismal fitness. Genomes have traditionally been viewed as cohesive units, with genes acting together to improve the fitness of the organism. Wikipedia

691 Koonin, E.V., Senkevich, T.G. & Dolja, V.V. 2006. The ancient Virus World and evolution of cells. *Biology Direct* 2006, 1:29 doi:10.1186/1745-6150-1-29. This article is available from: http://www.biology-direct.com/content/1/1/29

evidence is also needed to demonstrate that RNA can develop into an RNA-based virus and then into a primitive cell.

Viruses are not represented in Tree of Life diagrams because they are not capable of independent reproduction. Therefore, a virus is considered neither dead nor alive. A prerequisite for being classified as alive is the ability to reproduce independently, rather than parasitically as viruses do (by using another cell). Viruses require a host in which they insert their genetic material, which necessitates the prior presence of a host. In the 1980s, most scientists thought that viruses were merely escaped genetic fragments from living organisms, as they cannot replicate on their own and have no metabolism. Thus, they were not considered truly alive. The prevailing explanation during this period was that viruses evolved from genes in living cells.

In the absence of fossilised viruses, the evolutionary origin of viruses will likely remain controversial. However, there is no doubt that viruses have played an important role in creating genetic diversity and driving natural selection. This was evident during the recent COVID-19 pandemic, which killed over 7 million people worldwide by the end of 2022. Most of the deceased were elderly or had pre-existing health conditions, while the young and healthy were largely spared.

IX.4. The Rise of Humans

The formation of multicellular organisms was the starting point in building the Tree of Life. When environmental conditions vary, either locally, regionally or worldwide, traits which enhance survival in the environment also gradually vary. Those who survive the variation in conditions evolve to adapt to the new environment. This is the basis of the theory of Evolution and humans originated as part of this evolutionary process.

The characteristics of humans, both good and bad, go back to our ancestral origins. Humans gradually became civilised and modernised. We educated ourselves and became culturally, scientifically, and technologically advanced over time. However, some characteristics inherited from our animal lineage have remained.

We belong to the Homindae Family, Homininae Sub-Family, Homo Genus, and Homo Sapiens Species. In this lineage, humans and monkeys are both primates. We share a common ape ancestor with chimpanzees; because we both descended from the hominini tribe. Scientific findings suggest that primates diverged from other mammals about 85 million years ago, during the Late Cretaceous

period[692]. The earliest mouse-size primate fossils appeared in the Paleocene, around 55 million years ago[693].

Ian Tattersall[694] and Bosoh[695], based on fossil records, predicted that 6 to 2 million years ago humans were like tree-climbing walking apes, living in woodland and riverside. They had short legs, curved fingers, narrow shoulders, and small brains. They were naked, had dimorphic body sizes, legs adapted for bipedal walking, could climb trees, occasionally use stone tools, were omnivorous, and their diet was mostly fibrous vegetation. This changed during the period 2 to 0.2 million years ago. At that time, humans were like quadrupedal-running apes and hunting in hot savannah plains. They had long legs, short arms and narrow hips, and their brains were growing bigger. They ate meat, had a foraging diet, could use complex tools, and knew how to start fires.

Modern humans came into existence approximately 200,000 years ago. This claim is based on the findings of human fossils. These humans had skulls with modern cranial proportions, long hair, covered themselves with cloth, spoke some language, and could use tools. Our ancestors started wearing cloth only about 72,000 years ago[696,697].

Stringer's[698] investigations on mutation of male Y-chromosomes demonstrated that modern humans originated in Africa. At this time, large amounts of seawater were locked up in polar ice sheets. Sea levels were low, and the world was covered more in land masses than in oceans.

Walter et al.,[699] presented evidence suggesting that early humans lived along the east African coast of the Red Sea near Abdur, the present-day Eritrea. This was based on the findings of artefacts, such as axes and sharp obsidian cutting tools, found in a raised fossil reef. The fossil corals collected from this site were radiometrically dated to the last interglacial, about 125,000 years ago. The geological setting of these artefacts shows that early humans occupied coastal areas and exploited near-shore marine food resources. They reported the fossil findings of near-modern or modern *H. sapiens* from around this time in neighbouring East African places such as Omo Kibish (Ethiopia),

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692 https://en.wikipedia.org/wiki/Human_evolution

693 https://www.pbs.org/wgbh/nova/evolution/meet-your-ancestors

694 Ian Tattersall, 2012. Masters of the Planet: The Search for Our Human Origins, 266 pages. MacSci Series, Macmillan Science Series St. Martin's Press ISBN023010875X, 9780230108752

695 http://boscoh.com/longform/humanevolution/#header1

696 Kittler, R., M, Kayser, and M Stoneking. 2004, Molecular evolution of Pediculus humanus and the origin of clothing. *Current Biology 14:2309*

697 https://australian.museum/learn/science/human-evolution/when-and-where-did-our-species-originate/

698 Stringer, C. Coasting out of Africa. *Nature* 405, 25–27 (2000). https://doi.org/10.1038/35011166

699 Robert C. Walter et.al., 2000. Early human occupation of the Red Sea coast of Eritrea during the last interglacial. *Nature* volume 405, pages 65–69.

Singa (Sudan), Guomde (Kenya) and Skhul and Qafzeh (Israel). It is likely that these fossil findings were early members of our species (op. cit.).

J. Kingdon[700] proposed that Middle Palaeolithic people left Africa through the Levant and reached Southeast Asia 90,000 years ago. The findings of Walter et al.,[701] and other archaeological evidence[702] suggest that Australia was colonised about 50,000 years ago, before the Late Stone Age.

According to Nicholas Wade,[703] Caucasian skulls started appearing 16,000 years ago in the harsh climatic conditions of northern Europe. Wade also hypothesised the Mongols descended from another cold-climate-adapted population in north-eastern Asia.

At the end of the ice age about 10,000 years ago, evidence of human settlements started to appear in archaeological excavations. The oldest known large-scale settlement is a village called Çatalhöyük in Türkiye (Turkey), which dates back some 7,300 years ago[704]. The entrance to the village dwellings was from the roof, and bodies were buried inside the dwellings. Analysis of food remains suggests that the population were still hunter gatherers, and were not farmers. Bosco[705] wrote that from there on, palaeontology fits together with written history, as the Rig Veda (praise or verse of knowledge - one of the four sacred texts of Hinduism) and Old Testament Bible contain some traces of events occurring in this period of time.

A 7,300 BC Çatalhöyük Neolithic time settlement in Turkiye (Turkey). Model (Left); actual archaeological excavation site (Right).

[700] Jonathan Kingdon, 1993. *Self-Made Man and his Undoing*, 264 pp. Publisher: Simon & Schuster, London. ISBN-13: 9780671711405; ISBN-10: 0671711407;
Jonathan Kingdon, 2003. Lowly Origin: Where, When, and why Our Ancestors First Stood Up. 396 pp. Princeton University Press ISBN-13: 978-0691120287 or ISBN-10: 0691120285

[701] Walter, R. C. *et al. Nature* 405, 65–69 (2000).

[702] Stringer, C. *Antiquity* 73, 876–879 (1999).

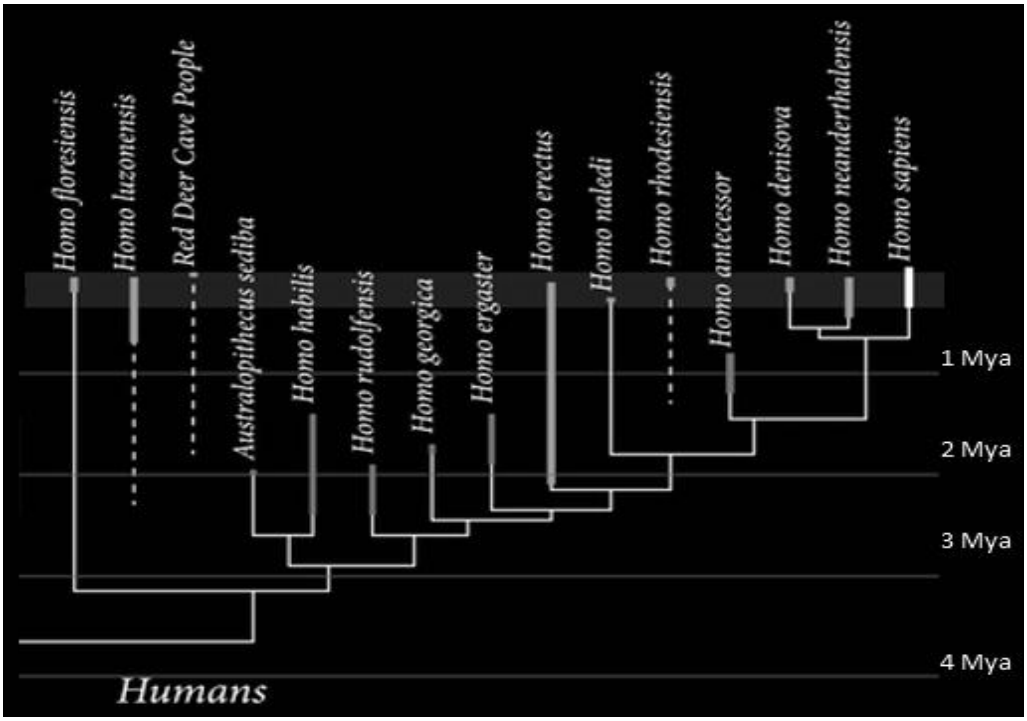
[703] Nicholas Wade, 2007, "Before the Dawn- Recovering the Lost History of our Ancestors" Penguin Group, ISBN 978-0-14-303832-0

[704] https://en.wikipedia.org/wiki/Çatalhöyük

[705] *Bosco Ho, 8/6/2014* http://boscoh.com/longform/humanevolution/#header1

There were several extinct human species before modern humans (homo sapiens) (op. cit.). These included *Homo neanderthalensis* who lived in Europe, the *Denisovans* who inhabited Asia, along with *Homo luzonensis* from the Philippines, *Homo floresiensis* ("hobbits") and *Homo erectus* who lived in Indonesia, *Homo rhodesiensis* from central Africa, and *Homo naledi* in South Africa. The cause of their extinction is difficult to know for sure, but Nicholas Wade suggests that it was not natural or environmental disasters but rather the spread of humans out of Africa and their destructiveness along their path. Once humans had risen, not only did they wipe out other prehistoric humans along their path, but everything else too: they hunted ice age mammals like woolly mammoths, giant ground sloths and the flightless bird moas (and many more) into extinction (op. cit.).

Nick Longrich (2019) [706] wrote *"nine human species walked the Earth 300,000 years ago but by 10,000 years ago, they were all gone. The disappearance of these species may resemble a mass extinction, but there was no obvious environmental catastrophe – volcanic eruptions, climate change, and asteroid impact – driving it".*



Timeline of human evolution. Source: Adapted from Nick Longrich https://www.sciencealert.com/did-homo-sapiens-kill-off-all-the-other-humans.

[706] Nick Longrich, 22 November 2019. Nine Species of Human Once Walked Earth. Now There's Just One. Did We Kill The Rest? THE CONVERSATION. https://www.sciencealert.com/did-homo-sapiens-kill-off-all-the-other-humans . Nick Longrich, *Senior Lecturer, Paleontology and Evolutionary Biology,* University of Bath, *UK.*

Longrich said, *"We are a uniquely dangerous species not only to animals we hunted to extinction but to other human populations, because we compete for resources and land".* He gave examples of people warring, displacing, and wiping out other groups over territory, from Rome's destruction of Carthage, to the American conquest of the West, and the British colonisation of Australia. There have also been more recent genocides and ethnic cleansing in Congo, Bosnia, Rwanda, Iraq, Darfur, Yemen, Myanmar and Ukraine. There is little reason to think that early Homo sapiens were less territorial, less violent, or less intolerant.

Most of such atrocities were because of population growth. Humans needed more pastoral land, a temperate climate and constantly running water. Atrocities began when people reproduce exponentially: unchecked, we historically doubled our numbers every 25 years (op. cit.).

Drought or harsh winters caused food shortages. This led tribes into territorial conflicts and wars, which were probably the most significant check on population growth (along with epidemic diseases like smallpox, flu, and measles). As we mentioned earlier, humans are more clever than all other animals, so we do not have any other predator animal to control our population. Nature and its elements, and some viruses or diseases, may kill a considerable number of humans, but we will always find a way to minimise the death toll.

Population growth was required for many reasons. In the past, a rising population in a rival tribe was considered a threat. Today, economic growth in nations is driven by an ever-increasing population. Increased trade between nations is viewed as a means of wealth creation and improving living standards. While wealth creation is beneficial, it can come at a cost when human greed goes unchecked.

Humans have built metropolises out of concrete, leaving barely any trees or forests to clean the air. We have stifled the environment we live in. We have burnt the lungs of the planet to plant crops, and mined the uranium, coal, oil, and gas deposits to the demise of the equilibrium set by Nature on Earth. The exponentially growing *Homo sapiens* species have successfully managed to turn anything good for humanity into a weapon, either to kill others or Nature itself. While the melting of glaciers is a catastrophe and another kick to the balance set by Nature, there are those eagerly waiting to get their hands on the untouched oil and gas deposits under the melting polar ice caps.

We used to be helpless when Nature unleashed its earthquakes, hurricanes, tsunamis, asteroid impacts, bushfires, and plagues upon us. But human ingenuity keeps finding solutions to every obstacle the universe puts in front of us. We build dikes to stop tsunamis and hurricanes, and we construct buildings to be earthquake resistant. We can now change the orbit of an asteroid well before it hits the Earth. Diseases like the Bubonic plague, smallpox, polio and tuberculosis used to

kill tens, if not hundreds, of millions of people in the past. Mass vaccination campaigns have now reduced the number of deaths from these types of diseases to a handful. Nature used to control our population, but for the most part, it does not any more.

Every nation must surely realise that if we ruin this planet, there is no other planet on which to find refuge. It is sad to contemplate, but as far as I can see, Nature has only one card left to play to sort out its “human plague problem”. Perhaps it is not by accident that there are aggressive people, and those who turn anything good for Nature or humanity into a weapon. It is possible that these dangerous characters exist to set the balance that Nature needs to survive.

CHAPTER X. THE MACHINERY THAT MAKES HUMANS TICK

"Human you are incredible; you are a physics defying, crossword cracking, dance crushing wonder machine"
Medibank Private Ltd. - A Health Insurer in Australia

The goal of this chapter is to highlight and remind ourselves how amazingly designed, astoundingly built, and how miraculously the human body operates. Every living being is an incredibly sophisticated biological machine, and their workings should be admired. It is inevitable to think there is intelligence behind all this, whether this intelligence is supernatural or natural.

Our bodies contain 100,000 miles of blood vessels and almost 40 trillion microbial cells[707]. The human body contains six main organs: the heart, brain, kidneys, liver, lungs, and nerves that are vital for our survival[708]. Even some of our organs are in pairs in case one fails to function. The heart is the organ which keeps blood flowing throughout the body. Blood carries required substances to cells, and it also takes waste away from cells. The brain is the body's control centre. It is the seat of all thoughts, memories, perceptions, and feelings. Two kidneys filter the blood, removing waste as urine and excreting this waste from the body. The liver's functions include filtering blood, secreting bile needed for digestion, and producing blood coagulation proteins. Uncontrolled bleeding may occur if these clotting proteins are not produced, or if vitamin K is not absorbed[709]. The liver produces most of the proteins found in blood (op. cit.). The lungs' main function is to exchange oxygen and carbon dioxide with the blood. The nervous system is equally vital for every living being. It is the electrical wiring of the body. Without this flow of electricity, we would be all in a vegetative state. The nerves streamline electrical charges and information to every part of the body.

There are many other important non-vital organs. These include the reproductive organs, digestive organs, the skin, veins to transport blood, muscles, and bones to keep the body's organs in their designated places.

Practically everything in our body, including our brain, heart, and entire nervous system, is controlled and enabled by electrical signals. The flow of electrons between atoms generates electricity. Since our bodies are made from cells, and cells are made from atoms in ionic form, our

[707] https://www.discovermagazine.com/the-sciences/5-amazing-things-about-the-human-body
[708] https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/10%3A_Introduction_to_the_Human_Body/10.4%3A_Human_Organs_and_Organ_Systems
[709] https://badgut.org/infprmation-centre/a-z-digestive-topics/thliver-an-amazing-organ

body generates electricity[710]. The electrical charges flow from one cell to the next, until reaching their destination - usually the brain via the nervous system.

The workings of the machinery that make us alive are investigated by scientists, who have shown us that everything can be explained by biochemical reactions. Let us provide some examples:

X.1. How Do We Perceive Things?

The first step in sensing the world around us involves converting electromagnetic radiation from the environment into information that the brain can use. This process of transforming energy from one form to another is called transduction[711]. All our senses begin with transduction in a sensory receptor, which is how environmental energy generates nerve impulses that encode information from the external world[712].

A sensory receptor is a living cell which responds to a particular type of energy. It does this by generating electrical potentials that influence neurons. Thus, receptors are transducers: they translate external energy to internal electrical impulses or gradients (op. cit.).

A receptor responds to a stimulus: any measurable input to the nervous system. Each type of receptor responds with exquisite sensitivity to a particular type of stimulation (op. cit.). For example, photoreceptors are image forming cells. They are a specialised type of neuroepithelial cell, which can absorb light and convert it into an electrical signal. This is done in the initial stages of the vision mechanism in a process known as phototransduction[713]. Photoreceptors are packed tightly together, allowing a large volume of light to be absorbed across a small area on the retina[714]. Photoreceptors in the retina are classified into two groups, named after their physical morphologies. Rod cells are overly sensitive to light and function in night-vision, whereas cone cells can detect a wide spectrum of light photons and are responsible for colour vision. There are approximately 4.6 million cone cells compared to an estimated 92 million rod cells located in the human retina. Rod cells function best in low-intensity light, and are thus responsible for vision in a dimly lit room (op. cit.).

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[710] Julia Layton and Mark Mancini, Aug 1, 2022. How Does the Body Make Electricity — and How Does It Use It? https://health.howstuffworks.com/human-body/systems/nervous-system/human-body-make-electricity.htm

[711] https://www.weforum.org/agenda/2017/01/humans-have-more-than-5-senses/

[712] https://www.psywww.com/intropsych/ch04-senses/receptors-and-stimulation.html

[713] https://en.wikipedia.org/wiki/Photoreceptor_cell

[714] https://www.kenhub.com/en/library/anatomy/photoreceptors

The brain coordinates all processes in the body to ensure that every cell, tissue, and organ is functioning as it should[715]. The brain learns by transforming information from physical stimuli such as touch, smell, heat, sound waves, or light, into electrochemical signals. It also stores relevant information so that it can be remembered in future. Our brains are arguably as effective as a super computer. Read on to find out more about how this powerful organic machine works.

The brain is composed of neurons (brain cells) in the cerebrum, cerebellum, brain stem, hypothalamus, the thalamus, and the medulla. Each of these regions of the brain perform different functions such as stimuli recognition, balance, involuntary and voluntary reflexes. The regions often operate in communication with each other. It is clear that without the brain recognising external stimuli, we would see nothing, hear nothing, feel nothing, be unable to breathe properly, and would remember nothing (op. cit.).

Once stimuli[716] are detected, the brain generates an appropriate reaction. Sensory receptors can receive information from outside the body (as in touch receptors found in the skin or light receptors in the eye), as well as from inside the body (like the heartbeat and breathing rate).

Receptors are often housed in a sense organ, a specialised structure constructed to collect one type of energy particularly well. Four types of receptors are known. Photoreceptors are those sensitive to light. Chemoreceptors respond to chemicals or molecular shapes of particles. Mechanoreceptors respond to physical touch or movement. Magnetoreceptors respond to magnetic fields. They are found in certain species such as shellfish, some bees, fish, pigeons, and turtles, but not in humans[717].

Mechanoreceptors[718] detect certain changes in the functioning of the body. These include homeostatic imbalances which can serve as internal stimuli, such as water, oxygen, and sugar levels in the blood. The normal state of the body is the equilibrium state. This state is maintained by self-regulating processes. The kidneys maintain homeostasis in the body by regulating the amount of salt and water excreted[719]. When a stimulus is detected by a sensory receptor, it provokes a reflex via stimulus transduction. An internal stimulus is often the first component of a homeostatic control system.

A chemoreceptor is a specialised sensory receptor cell which transduces a chemical substance to generate a biological signal[720] to external stimuli. External stimuli can produce systemic responses

[715] http://www.actforlibraries.org/how-does-the-brain-store-information/
[716] https://en.wikipedia.org/wiki/Stimulus_(physiology)
[717] https://www.psywww.com/intropsych/ch04-senses/receptors-and-stimulation.html
[718] https://en.wikipedia.org/wiki/Mechanoreceptor
[719] https://www.thefreedictionary.com/homeostatic
[720] https://en.wikipedia.org/wiki/Chemoreceptor

throughout the body. In order for a stimulus to be detected with high probability, its level of strength must exceed the absolute threshold. If a signal reaches the threshold, the information is transmitted to the central nervous system[721]. It is then integrated and a decision on how to react to it is made.

The central nervous system (CNS) consists primarily of the brain and spinal cord. The brain integrates received information, coordinates and influences the activity of all parts of the human body. The CNS is a large nerve running from the anterior to the posterior, with the anterior end enlarged into the brain. Not all animals with a central nervous system have a brain, although the large majority of them do.

Sensory information is repeatedly transformed by the algorithms of the brain in both bottom-up and top-down processing. Top-down processing involves the brain sending down stored information to the sensory system, as it receives information from the stimulus. This allows for a plausible hypothesis to be made, without the need to analyse every feature of the stimulus[722]. The bottom-up process involves information travelling up from the stimuli via the senses to the brain, which then interprets it relatively passively[723].

Once information is partially processed, an attention filter decides how important the signal is and directs it to the appropriate cognitive processes[724]. This attention mechanism acts like a searchlight, highlighting relevant stimuli while filtering out the rest[725]. There are multiple stages of processing, and attention continuously modulates the results at each stage.

Attention is the ability of the brain to selectively concentrate on one aspect of the environment while ignoring other things[726]. There are two types of attention in two separate regions of the brain. The prefrontal cortex is located directly behind the forehead, at the anterior part of the frontal lobe of the brain. It is one of the functional areas of the frontal lobe and oversees wilful concentration (op. cit.).

For example, if you are doing an exam, the impetus and orders come from the prefrontal cortex. But if a bell rings suddenly during the exam or another alarming event occurs, it is the parietal cortex (located behind the ear) which is activated. In these two brain regions, concentration is sustained when neurons emit pulses of electricity at specific rates. The parietal region emits faster

721 https://en.wikipedia.org/wiki/Central_nervous_system
722 https://www.simplypsychology.org/top-down-processing.html
723 https://www.verywellmind.com/bottom-up-processing-and-perception-4584296
724 https://www.teach-nology.com/teachers/methods/info_processing/
725 https://www.quantamagazine.org/to-pay-attention-the-brain-uses-filters-not-a-spotlight-20190924/
726 https://inside-the-brain.com/2013/03/07/what-is-attention-and-where-is-it-in-the-brain/

frequencies for automatic processing, while the prefrontal region emits slower frequencies for deliberate, intentional work (op. cit.).

Scientists have long believed that the prefrontal cortex selects which information to focus on[727]. When we focus our attention on one type of stimuli, we can filter out distracting stimuli that does not fit the parameters[728]. In the exam example mentioned above, you were instructed to pay attention to finishing the test on time, but your brain will register if a student sitting close to you starts chewing on his pencil or breathing heavily as distracting information.

For the brain to process information, it must first be stored. This stored information becomes a memory which can be recalled at a later time. For information to be stored, it needs to be encoded.

The workings of the human brain are discussed in some detail later in this chapter.

X.2. How Do Cells Produce Electricity?

Electricity is generated in cells, and nearly all our cells can generate electricity. But how does this happen? Cells control the flow of charged elements across cell membranes, with proteins that sit on the cell surface through openings of ion channels which allow only certain ions to pass through. When a cell is stimulated by touch, smell, voice, light, taste or other means, it allows positively charged ions to enter the cell through the ion channels. This makes the inside of the cell more positively charged, and triggers electrical currents which can turn into electrical pulses called action potentials. Action potentials initiate actions like thoughts, the experience of pain or pleasure in the brain, or making the heartbeat[729].

Cells are negatively charged in their natural or resting state. This negative charge is related to a slight imbalance between the charged atoms located inside and outside the cells. It is this imbalance which sets the stage for the electrical activity in our body.

The charged elements which play an important role are ions, mainly sodium (Na^+), potassium (K^+), and calcium (Ca^{++}). These ions are positively charged. Chloride (Cl^-) and sulphate ($SO_4^=$) ions are negatively charged. Each ion has its own ionisation energy. For example, 11th ionisation energies (the energy required to remove an electron) of Na+, K+ and Ca++ are 1646.702, 564.7 and 581.9 eV[730], respectively. The difference in ionisation energies of these atoms creates a charge imbalance. When the cell is not transmitting electrical signals, there will be a higher concentration of sodium

[727] https://www.nih.gov/news-events/nih-research-matters/mapping-brain-circuits-involved-attention

[728] https://theness.com/neurologicablog/index.php/the-brains-filter/

[729] https://www.graduate.umaryland.edu/gsa/gazette/February-2016/How-the-human-body-uses-electricity/

[730] *David R. Lide (editor-in-chief) (2003–2004). "Section 10. Atomic, Molecular, and Optical Physics".* Ionization Potentials of Atoms and Atomic Ions (PDF). *CRC Handbook of Chemistry and Physics (84th edition). CRC Press. pp. 10-178 to 10-180*.

ions outside the cell than inside the cell. On the other hand, there will be more potassium ions inside the cell than are outside[731]. This charge difference on each side of the cell membrane establishes an electrochemical gradient between what is inside the cell and the area immediately outside it.

Ions enter or exit a cell through their specific ion channels, akin to gates, located in the cell membrane. They only allow their specific kind of ion to pass through. A brief outline of this process is as follows:

When a cell is in the resting membrane potential stage, sodium and potassium ions are both present on either side of the cell membrane. The charge difference in total between inside and outside of the cell is called the membrane potential.

A change in the cell's membrane potential activates some of the relevant ion channels which are embedded in the cell membrane. The change in cell's membrane potential happens once the interior total charge fluctuates in relation to the exterior total charge.

The voltage-gated ion channels open, allowing the transfer of ions only when the cell's membrane potential has shifted by the right amount. Each voltage-gated ion channel only allows a particular kind of ion to enter or exit the cell.

Neurons are found in the brain, spinal cord, and in the peripheral nerves. Neurons are cells in the nervous system specialised in transmitting information across the body. They contain both potassium and sodium voltage-gated ion channels in their membranes. The cell's membrane potential changes when these ions enter the neuron. If enough ions pass through, the cell will no longer be at its resting membrane potential.

Action potentials within neurons allow the cells to communicate with each other. If you ate a hot chilli pepper and your mouth was burning, the neurons in your mouth send this sensation as a message to your brain. An action potential is a rapid sequence of changes in the voltage across a membrane. It is akin to a shockwave which comes in two phases: depolarization, followed by repolarization.

The hot chilli in your mouth will trigger an opening of a sodium voltage-gated ion channel along the cellular membrane of the closest neuron. Sodium ions will suddenly come pouring into the cell, changing the resting membrane potential. The rapid increase of sodium ions will make the inside of

[731] Julia Layton and Mark Mancini, Aug 1, 2022. How Does the Body Make Electricity — and How Does It Use It? https://health.howstuffworks.com/human-body/systems/nervous-system/human-body-make-electricity.htm

the cell more positively charged than the space surrounding it - the opposite of the resting membrane potential. This is referred to as the depolarization state.

The sodium influx causes the internal voltage to rise. The neuron will quickly enter its repolarization state when the cell ejects sodium ions and pulls in potassium. This process reinstates the resting membrane potential, and once again the inside of our neuron becomes more negatively charged than the outside.

Depolarization and repolarization create action potentials, like electrical shockwaves. They are instigators, setting off a chain reaction among neurons and informing the brain of a signal upon which to act. It is these types of electrical signals that tell you things like run for a glass of water, or tell your heart muscles to contract, or tell your brain to do something.

This is one of the most admirable and well-designed functioning examples of the living body. Another commendable example of electricity in the human body comes from the workings of the heart, and its generation of heartbeats.

X.3. Electrical Workings of The Heart BEAT

The heart is an electrical organ. It depends on precise electrical signals in order to contract and pump blood. The heart supplies nutrients and oxygen to every part of the body by a network of arteries, veins, and capillaries. It also takes away waste which is generated by cells and organs.

Brain requires oxygen to remain functional. Stopping of the heart causes the brain to die. The heart rhythmically contracts and relaxes to pump blood to the brain, lungs and entire body. These rhythmic contractions and relaxations are referred to as heartbeats.

The rhythm in a working heart is regulated by electrical impulses, generated by the flow of electrolytes[732]. Any interruptions or irregularities in heartbeats can lead to a variety of problems, including an eventual heart attack and even death.

The workings of heart's electrical system are explained clearly by the Cleveland Clinic website so for detailed information please refer to the footnote below[733]. The heart's conduction system allows it to beat[734]. The brain sends signals to the heart's electrical system through the autonomic nervous system. This activates the heart's electrical system, sending an electrical pulse through the heart

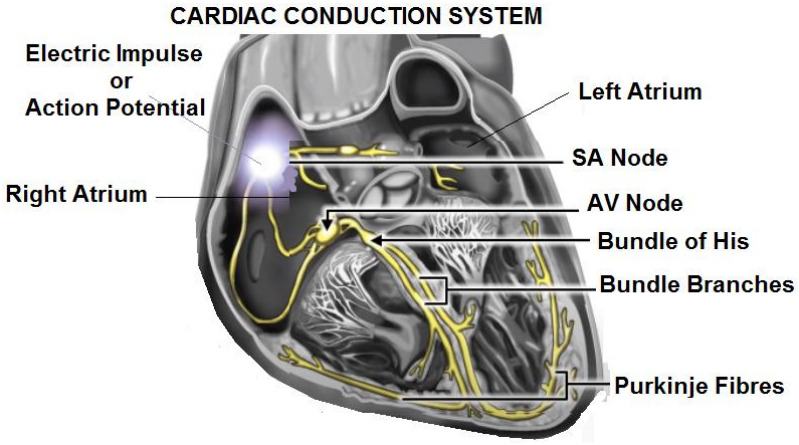
[732] Electric signals between individual cardiac cells regulate heartbeat by American Institute of Physics July 13, 2021. https://medicalxpress.com/news/2021-07-electric-individual-cardiac-cells-heartbeat.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

[733] https://my.clevelandclinic.org/health/body/21648-heart-conduction-system

[734] Cardiac muscle cells are typically rectangular in shape compared to the long, fibre-like shape of skeletal and wheel- or oval-shaped smooth muscle cells.

muscle. The electrical pulse makes the chambers of the heart squeeze in a specific order, creating a heartbeat.

The heart's electrical system controls the timing of heartbeats by sending an electrical signal through these cells. The cardiac conduction system includes specialised cells and nodes as shown in figure below. These are the sinoatrial node, the atrioventricular node, the bundle of His, and the Purkinje fibres.



The cardiac conduction system of the heart. The yellow channels show the electricity conducting cells. The bright spot is where the electric impulse is created.

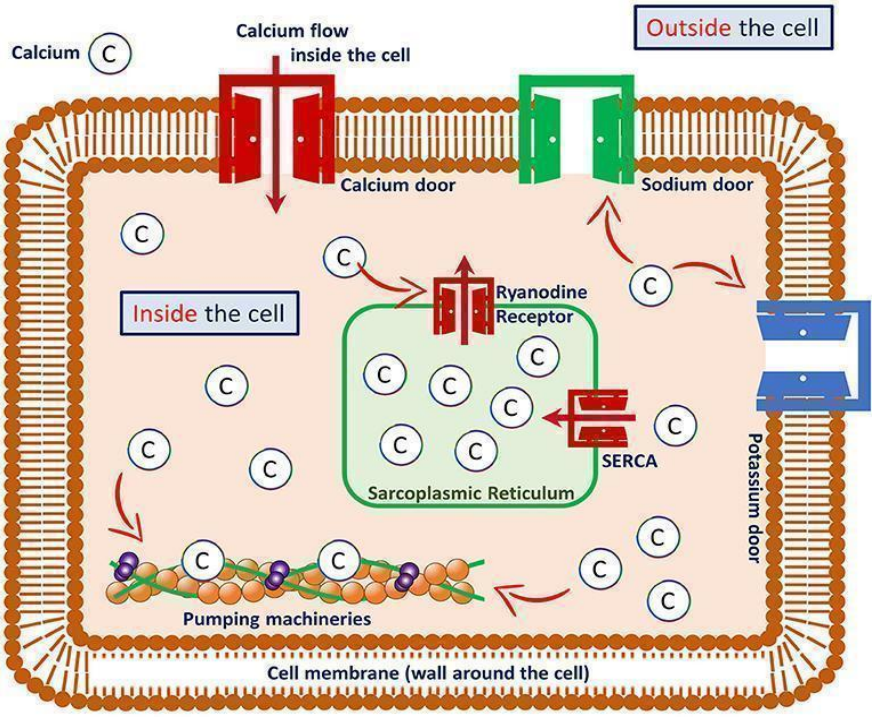
Among many other things, the heart consists of 3 billion heart muscle cells. These cells contract during each heartbeat. Together, they are responsible for the blood pumping function of the heart. The heart beats continuously, whether you are asleep or awake. It relies on a specific part of the nervous system - the autonomic nervous system (ANS) – to do this[735]. The ANS is the unconscious part of the nervous system. It runs automatic bodily functions like those of the heart, breathing, and digestion.

The heart is a living body's engine and works something like the engine in a car. Broadly speaking, the heart's chambers can be likened to car engine's pistons, the contraction of the heart's chambers acts like the piston stroke, and the ignited gas is the blood which keeps everything going. The heart even has a spark plug setup to start, as explained below.

The heart rate can adjust depending on messages coming from the brain and other parts of the body. A faster heart rate delivers more blood, and therefore more oxygen, to the body. During periods of rest or sleep, the body needs less oxygen and so the heart rate decreases.

[735] The autonomic nervous system includes sympathetic nervous system (fight or flight response) and parasympathetic nervous system (rest and digest response).

The cardiac cycle starts when an electrical impulse, like the spark plug of a car, or action potential, is generated by the SA (sine atrial) node (see figure below). The electrical signal travels from the SA node along specialised conducting fibres or cardiac conduction systems in the walls of the atria. This stimulates the atria to contract and pump blood into the ventricles. In a normal heart, the impulse travels very rapidly and produces a coordinated pumping action[736].



A heart muscle cell and its sodium, calcium and potassium ion channels (akin to doors or gates). SOURCE: Henry Sutanto and Jordi Heijman, The Role of Calcium in the Human Heart: With Great Power Comes Great Responsibility. Frontiers for Young Minds, CORE CONCEPT HUMAN HEALTH Published: May 10, 2019; https://kids.frontiersin.org/articles/10.3389/frym.2019.00065#KC7

The body controls the heart rate by the sympathetic and parasympathetic nervous systems. These nerves have endings in the heart. Both systems are made up of very tiny nerves which travel from the brain or spinal cord to the heart. The sympathetic nervous system is triggered during stress, or a need for increased cardiac output in a fight or flight situation. It sends signals to the heart to increase its rate. The parasympathetic system is active during periods of rest and digestion, sending signals to the heart to decrease its rate.

[736] Rakesh K. Pai et.al., April 29, 2021. Healthwise Staff. https://myhealth.alberta.ca/Health/Pages/conditions.aspx?hwid=te7147abc ; https://health.howstuffworks.com/human-body/systems/circulatory/heart-rhythm.htm

The electrical signal then arrives at a group of cells at the bottom of the right atrium called the atrioventricular (AT) node. The AT node briefly slows down the electrical signal, giving the ventricles enough time to expand and fill up with blood. When the electrical signal leaves the AT node, it travels down a bundle of conduction cells which divide the signal into two branches. One branch goes to the left ventricle, and the other goes to the right ventricle.

These branches divide further into bundle branches and through the Purkinje fibres. This spreads the signal through the left and right ventricles, causing them to contract. When the ventricles contract, the right ventricle pumps deoxygenated blood to the lungs, while the left ventricle pumps oxygenated blood to the rest of the body. Following the contraction of the atria and ventricles, each part of the system electrically resets itself. The SA node then sends another signal to the atria to contract, which starts the cycle over again. This cycle of an electrical signal followed by a contraction is one heartbeat. You can watch this process animated on YouTube: https://www.youtube.com/watch?v=ftn4YqybQww and https://www.youtube.com/watch?v=fZT9vlbL2uA

The body controls cardiac output by using hormones. When the body is under stress, the adrenal glands release a hormone called norepinephrine into the bloodstream, while the sympathetic nervous system is triggered to increase the heart rate. Norepinephrine causes the heart to beat faster. Unlike the sympathetic nervous system, which sends an instantaneous and short-lived signal, norepinephrine released into the bloodstream increases the heart rate for several minutes or more.

The steps involved in the cellular workings of the heartbeat are as follows: Heart cells allow ions of Na+, K+ and Ca++ spontaneously into the cells. This produces electrical impulses in the pacemaker cells which spread over the heart, causing it to contract. Pacemaker cells are highly specialised myocardial (cardiac muscle) cells with an intrinsic ability to depolarize rhythmically and initiate an action potential[737]. The pacemaker cells are located primarily in the sinoatrial or sinus node and atrioventricular nodes, with some cells also in the bundle of His and Purkinje fibres. It is located at the junction of the crista terminalis in the upper wall of the right atrium and the opening of the superior vena cava. The integrated activity of the pacemaker cells causes the sinoatrial node to generate electrical impulses which set the rhythm and rate of the heart. The mass of the sinus node is too small to create a substantial electrical signal that can be detected on the electrocardiogram[738].

[737] Z Xingyu Wei; Sandesh Yohannan; John R. Richards. 21 Apr 2022 Physiology, Cardiac Repolarization Dispersion and Reserve https://www.ncbi.nlm.nih.gov/books/NBK537194/

[738] https://www.ncbi.nlm.nih.gov/books/NBK459238

A heart muscle cell is like a house with multiple entries called gates or ion channels, or simply channels[739]. The electrical impulses which make the heart muscle cells contract and relax are created by the movement of charged sodium, potassium, and calcium ions through these channels and between cells (Sarhan et al 2012)[740]. The channels allow charged particles, namely ions of K^+, Ca^{++}, Na^+, and Cl^-,[741], to enter or leave the cell. The ion channels help the cell to control the number of ions inside of it. Recently, scientists have found that calcium can regulate the activity of other ions, making them easier or harder to open. This highlights the importance of calcium to heart muscle cells[742].

In addition to the supply of these ions from outside the cell, there is a big chamber inside the cell. The inner chamber, named the sarcoplasmic reticulum, stores most of the calcium required for heart contraction. The sarcoplasmic reticulum chamber has entrance and exit doors for calcium. The entrance doors to the sarcoplasmic reticulum are named SERCA and the exit doors are named ryanodine receptors.

Calcium entering a heart cell through the calcium ion channel activates the ryanodine receptor to release enough calcium from the sarcoplasmic reticulum to initiate heart muscle contraction. This is done by calcium binding to troponin complex, a complex structure of three regulatory proteins which are integral to muscle contraction. These three regulatory proteins are called troponin C (TnC), troponin T (TnT), and troponin I (TnI). They are integral to non-smooth muscle contraction in cardiac muscle[743]. They are located between actin[744] filaments of muscle tissue.

Troponin C binds to calcium ions and produces conformational change in TnI. Troponin T binds to tropomyosin, and Troponin T binds to actin. During relaxation, calcium must be detached from troponin and expelled out of the cell, or stored back inside the sarcoplasmic reticulum. Calcium also regulates the opening and closing of sodium and potassium channels. The potassium channels outnumber the sodium channels in most cells.

Sarhan et al (2012) have revealed that the movement of sodium in and out of cells also contributes to the beating of heart cells. In this process, a protein called calmodulin plays a major role by

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[739] Sutanto H and Heijman J (2019). The Role of Calcium in the Human Heart: With Great Power Comes Great Responsibility. Front. Young Minds. 7:65. doi: 10.3389/frym.2019.00065 https://kids.frontiersin.org/articles/10.3389/frym.2019.00065

[740] M.F. Sarhan, et al. Crystallographic basis for calcium regulation of sodium channels. *Proceedings of the National Academy of Sciences*, 2012 DOI: 10.1073/pnas.1114748109; https://www.sciencedaily.com/releases/2012/02/120213185645.htm

[741] Ionic radii of K+ = 2.8A; Ca++ = 2.31A; Na+ = 2.27A and Cl- = 1.75Angstrom

[742] Heijman, J., Schirmer, I., and Dobrev, D. 2016. The multiple proarrhythmic roles of cardiac calcium-handling abnormalities: triggered activity, conduction abnormalities, beat-to-beat variability, and adverse remodelling. *Europace.* 18:1452–4. doi: 10.1093/europace/euv417

[743] https://www.sciencedirect.com/topics/veterinary-science-and-veterinary-medicine/troponin

[744] Actin is a protein that forms (together with myosin) the contractile filaments of muscle cells, and is also involved in motion in other types of cells.

binding to the sodium channel and keeping it open. This is done by the calcium ions by causing the protein to hook up to the channel, keeping it open and letting sodium through.

Along with sodium, potassium regulates the water balance and the acid-base balance in the blood and tissues. It also plays a critical role in the transmission of electrical impulses in the heart. The active transport of potassium into and out of cells is crucial to cardiovascular and nerve function. When potassium enters the cell, it instigates a sodium-potassium exchange across the cell membrane. When potassium leaves the cell, it restores repolarization to the cell, which allows the nerve impulse to progress. This electrical potential gradient helps generate muscle contractions and regulates the heartbeat[745].

Most heart problems, like heart rhythm disorders or uncoordinated, chaotic electrical activity of the heart (fibrillation), are due to malfunctioning of the channels controlling movement of sodium, calcium, and potassium ions[746].

Each heartbeat is a contraction of the heart, which forces blood from one point to another. Every spurt of blood carries fresh oxygen to organs and everywhere else in the body[747]. Without this fresh oxygen, organs like the brain would die very quickly.

When blood returns to the heart from the rest of the body, it flows into the right atrium. The oxygen in this blood needs replenishment. The right ventricle sends the blood into the lungs for an oxygen refill. Once the blood has picked up oxygen, it moves from the lungs to the left atrium, and then down into the left ventricle. The right and left atria contract at the same time, and then the ventricle contracts. The right atrium pushes blood which is low in oxygen into the right ventricle. The left atrium pushes oxygenated blood from the previous cycle into the left ventricle. When the left ventricle contracts, it propels oxygenated blood into the aorta, from where it is distributed to the rest of the body. The blood eventually returns to the right atrium, low in oxygen, and the process starts again.

In each heartbeat, the atrium must contract first, otherwise the ventricles will run low on blood and their contractions will not be effective.

Those interested in knowing more about the workings of heart cells should refer to the footnote below[748].

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[745] Kowey, P.R. (2002). The Role of Potassium. In: Lobo, R.A., Crosignani, P.G., Paoletti, R., Bruschi, F. (eds) Women's Health and Menopause. Medical Science Symposia Series, vol 17. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-1061-1_18

[746] https://kids.frontiersin.org/articles/10.3389/frym.2019.00065

[747] https://health.howstuffworks.com/human-body/systems/circulatory/heart-rhythm.htm

[748] 1. https://courses.lumenlearning.com/suny-ap2/chapter/cardiac-muscle-and-electrical-activity/

X.4. ALL IN THE BRAIN

Humans are more intelligent than other animals, not because of their higher brain to body size ratio, but because they have more neurons and glia (brain cells) per unit volume in their brain compared to any other mammal. The intelligence of other animals is inferior to that of humans, because they have a smaller number of neurons in their brain[749].

The human brain is made up of 86 billion neurons, among its other components. These neurons can form over one trillion connections. A piece of brain tissue the size of a single grain of sand contains 100,000 neurons and 1 billion synapses, all communicating with each other[750]. For all this to fit inside the organ, the brain has developed a wrinkled structure in its outer layer, called the cortex. This increases the surface area to volume ratio[751].

The brain is a complex organ which controls our thoughts, memories, emotions, motor skills, vision, breathing, body temperature, hunger and every other process that regulates our body. Together, the brain and spinal cord which extends from the brain stem, make up the central nervous system.

For further reading about the brain and nervous system please refer to the link in footnote[752].The average adult brain weighs about 1.5 kilograms. It is composed of approximately 60% fat, with the remaining 40% being made up of water, protein, carbohydrates, and salts[753].

On a scan, a cross section of the brain appears as shades of grey and white. These colour differences are often referred to as grey and white matter regions. Grey matter is the darker, outer portion, while white matter describes the lighter, inner section (refer to the left figure below). Differences in the composition of parts of the brain cause these colour differences. Grey matter is primarily composed of neuron somas (round central cell bodies). White matter is mostly made of axons, the long stems which connect neurons together, wrapped in a protective coating named myelin.

The brain is a random thought generator. All emotions, thoughts, feelings, experiences, and personalities, are generated in the brain. The two frontal lobes of the brain are associated with self-control, planning, logic, and abstract thought —things which make us particularly human[754].

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2. Bartos, D. C., Grandi, E., and Ripplinger, C. M. 2015. Ion channels in the heart. *Compr. Physiol.* 5: 1423–64. doi: 10.1002/cphy.c140069
3. Sutanto, H., van Sloun, B., Schonleitner, P., van Zandvoort, M., Antoons, G., and Heijman, J. 2018. The subcellular distribution of ryanodine receptors and L-type Ca^{2+} channels modulate Ca^{2+}-transient properties and spontaneous Ca^{2+}-release events in atrial cardiomyocytes. *Front. Physiol.* 9:1108. DOI: 10.3389/fphys.2018.01108

749 John Barrow and Frank Tipler. The Anthropic Cosmological Principle. Oxford Paperbacks, Published: 7th April 1997, ISBN: 9780192821478, Number of Pages: 738

750 https://www.medicaldaily.com/human-brain-numbers-neurons-spinal-fluid-391974

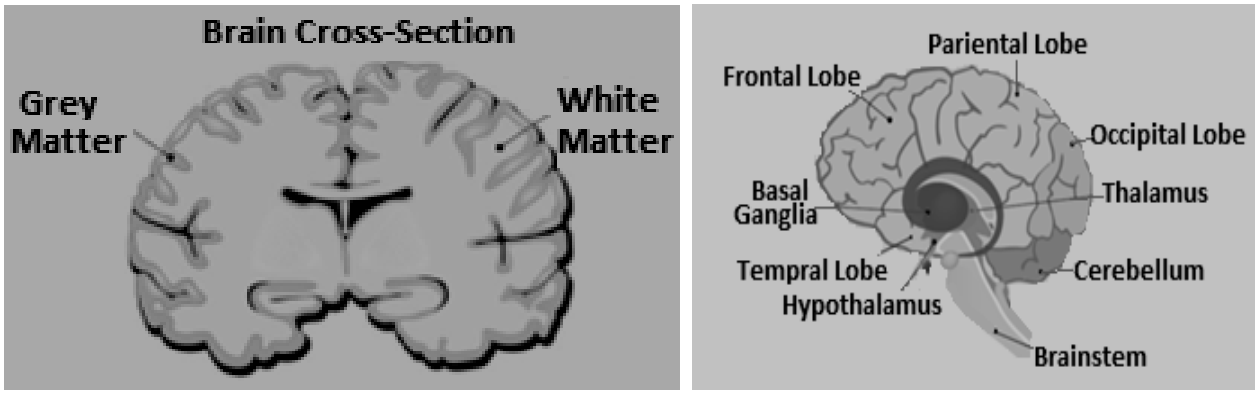
751 https://www.livescience.com/29365-human-brain.html

752 https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain or an Anatomy book

753 https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain

Some people can memorise whole deck of playing cards, and then predict what the next card will be, when you draw a card from a shuffled play deck[755]. This requires significant effort and training of the brain.

There are four lobes of the brain: the frontal lobe, the parietal lobe, the temporal lobe, and the occipital lobe. Other major sectors include the basal ganglia, hypothalamus, thalamus, cerebellum, and the brain stem. The regions and segments of the brain are shown in figure below.



Segments of the human brain.

Each part of the brain is responsible for different things:

- Frontal lobe: decision making, problem solving, emotions and consciousness
- Parietal lobe: perception, sensation and spatial reasoning
- Temporal lobe: memory, learning, hearing and language
- Occipital lobe: vision
- Basal ganglia: movement
- Hypothalamus: thirst, hunger, sleep and mood
- Thalamus: the sensory relay centre
- Cerebellum: balance, posture and coordination
- Brain stem: heart rate, blood pressure, breathing and swallowing

The brain is made up of cells, mainly neurons and glia. There are three types of glia, known as oligodendrocytes, microglia, and astrocytes. A neuron is made up of three basic parts, the soma

[754] https://www.livescience.com/29365-human-brain.html
[755] https://artofmemory.com/wiki/Card_Memorization_Techniques/

(body), dendrites, and the axon. The dendrites receive signals from other neurons. The axon sends signals to surrounding neurons, through the axon terminal as shown in figure below.

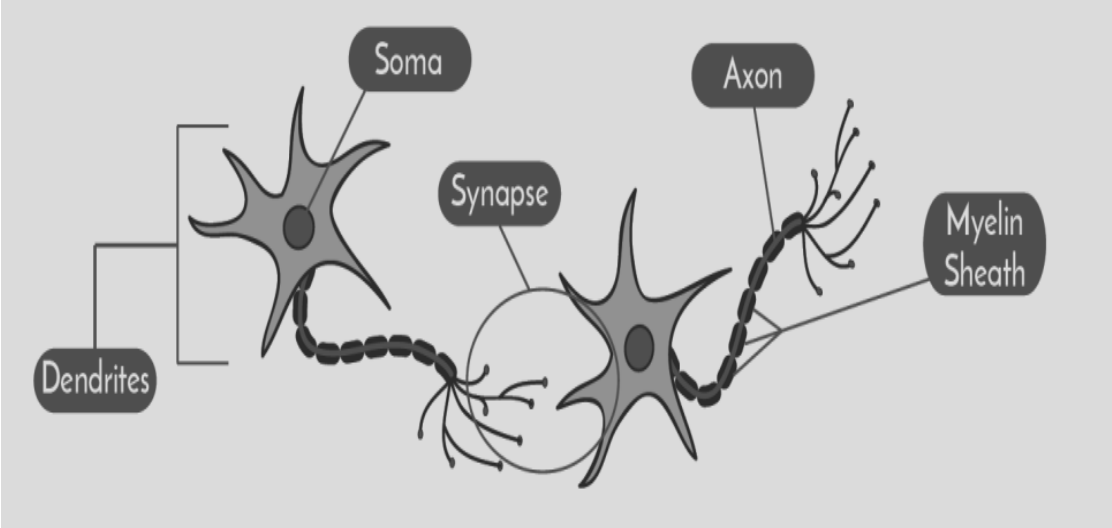


Illustration of how two brain cells (neurons) communicate.

SOURCE: Elizabeth A. Weaver II and Hilary H. Doyle, August 11, 2019. How Does the Brain Work? https://www.dana.org/article/how-does-the-brain-work/

Without neurons, we would not be able to think, feel, remember, or comprehend the world around us. Neurons communicate with each other and transmit information to every part of the body, by sending and receiving electrical and chemical signals[756].

Neurons release chemicals known as neurotransmitters, which generate electrical signals in neighbouring neurons. These signals are created by the flow of electrically charged ions in and out of the neuron cell membrane. Glia (the Latin word for glue) actively participates in brain signalling. They are needed for the healthy functioning of neurons.

When a neuron fires an action potential, electrical and chemical signals travel from the axon of one neuron to the dendrites of another, across a small gap called the synapse. This process begins when a resting neuron receives a stimulus from one of the five senses, causing its negative charge to become more positive. Once the neuron reaches a certain threshold, an action potential is triggered, causing the neuron to "fire." The action potential travels down the axon to the axon terminal, where the electrical signals are converted into chemical signals which cross the synapse as neurotransmitters.

[756] Cells of the Brain by Elizabeth A. Weaver II and Hilary H. Doyle; https://dana.org/article/cells-of-the-brain/

Neurotransmitters activate receptors on the dendrites of neighbouring neurons, allowing the signal to continue. Dendrites are branch-like projections which carry impulses to the soma of the neuron (op. cit.). This interaction between the neurotransmitters and receptors can be compared to a key fitting into a lock, transmitting the message and then recycling the neurotransmitters (op. cit.).

This communication between neurons underlies all cognitive functions, from thinking and problem-solving, to playing sports and even dreaming (op. cit.). Unlike neurons, glial cells do not fire action potentials. They use chemical signals to communicate with each other and with neurons (op. cit.).

According to Harrison et al. (2023)[757], the neural model suggests that human brains are evolutionarily wired to function like supercomputers in processing visual information. Their mathematical modelling demonstrates our human brains naturally perform complex calculations, resembling high-powered computers, to interpret the world through a process known as Bayesian inference.

Bayesian inference is a statistical method which integrates prior knowledge with new evidence, enabling intelligent guesswork through the calculation of probabilities. This inherent design allows our brains to effectively analyse surroundings, although the precise mechanisms behind these calculations remain largely mysterious.

In healthy aging, the brain typically undergoes some degree of shrinkage without significant neuron loss[758]. However, conditions like Alzheimer's disease lead to brain shrinkage alongside widespread neuron loss. When neurons cease functioning and lose connections, communication, metabolism, and repair processes are disrupted. This ultimately causes deterioration and death of these cells. (op. cit.). Excessive alcohol consumption and substance abuse can also markedly reduce neuron numbers.

Humans may be insignificant in size or shape in this universe, but the present design of our brains gives us several superiorities over every other living being on this planet. It is through our brains that we can imagine or dream of things without limitation. This imaginative scaffolding allows us to investigate the past and the future.

It is the dreamers who create new concepts, even if those concepts may not seem to make any sense at the time. The brains of exceptionally intelligent dreamers have allowed humankind to reach our

[757] William J. Harrison et al, Neural tuning instantiates prior expectations in the human visual system, Nature Communications (2023). DOI: 10.1038/s41467-023-41027-w; https://medicalxpress.com/news/2023-09-neural-evolution-wired-human-brains.html

[758] https://www.nia.nih.gov/health/what-happens-brain-alzheimers-disease .

present level of science and technology: we can build skyscrapers, go to space, and build nano-size machines. We may not have the eyes of a hawk, but we can build thermal cameras to allow us to see in the dark, or high-speed cameras to capture 20,000 frames per second[759], better than the sharpest eye of any animal. None of these technological advancements would be possible without our advanced brains and ability to think in abstract terms.

X.5. How The Mind and Brain Are Related

How the human mind came into existence is a billion-dollar question. The mind is the mental output of the brain's activities like thoughts, feelings, desires, reasoning, self-awareness, imagination, remembering, and sensation[760]. The brain controls and coordinates movements, thoughts and feelings, memories, every emotion, the five senses, breathing, hunger, body temperature, and every process performed by the body. These activities originate from the brain and are felt through the mind. The brain is the physical substance, and the mind is the conscious output of these activities[761].

Mental activities of the brain arise from the interaction of neurons through synaptic connections[762]. Mirror neurons and spindle cells, in particular, play crucial roles in expressing empathy and processing social information. These mental activities are generated by electrical signals propagating through neurons, creating wave-like patterns[763]. In essence, the mind is a product of these firing neurons[764]. Specific oscillation patterns enable neurons in different brain regions to communicate effectively. This brain activity can result in sensations like the burning feeling from eating a hot chilli chicken-laksa or the loud sound of a passing train.

The brain is a vital organ essential for the body's operation, while the mind engages in activities not critical for bodily functions. The mind operates in the background, often without our conscious awareness[765]. It never stops working, except partially during deep sleep or when the brain is damaged or sedated. Even during deep, non-REM (non-rapid eye movement) sleep, the brain

[759] https://techxplore.com/news/2021-07-high-speed-cameras-reveal-blooming.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

[760] https://www.mindbodygreen.com/articles/difference-between-mind-and-brain-neuroscientist and http://www.differencebetween.net/science/health/difference-between-mind-and-brain/#ixzz7dEsZRR1M

[761] https://qz.com/866352/scientists-say-your-mind-isnt-confined-to-your-brain-or-even-your-body/

[762] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3914914/

[763] https://www.pressconnects.com/news/local/2019/03/18

[764] https://qz.com/866352/scientists-say-your-mind-isnt-confined-to-your-brain-or-even-your-body/

[765] https://www.livescience.com/can-you-ever-stop-thinking

continues to generate slow electrical oscillations, known as slow waves. This phase is crucial for memory consolidation, the process of transferring new memories into long-term storage[766].

When the mind ceases to function, it is termed a loss of consciousness. Death occurs when the body, brain (mind), and every cell in the body stop functioning. Clinically, death is defined by the cessation of the heart, because within minutes, the rest of the body's cells begin to shut down as well.

The living body can also belong to an animal, which may exhibit varying levels of mental sophistication compared to the human mind. Scientists now agree that animals, from rats and mice to parrots and humpback whales, possess complex mental capacities (even though we cannot fully gauge their extent due to communication barriers). Many animals, especially crows, whales, dolphins, chimpanzees, orangutans, gorillas, elephants, foxes, parrots, and magpies, have developed distinctive skills. They learn these skills by imitating each other, learning from their parents, or being taught by humans in environments like zoos, aquariums, or circuses.

Humans are not unique in possessing the neurological firing mechanisms essential for a working mind. Animals, including all mammals and birds, and many other creatures also engage in such neurological activities within their brains. However, it is clear that no animal possesses the full range of attributes and sophistication of the human mind. Yet, many attributes of human mind are found in one or another animal,[767] suggesting that we adopted these traits from other animals during our biological evolution. For instance, the ability to recognise oneself in a mirror, a common test of self-awareness, is seen in chimpanzees but not in dogs. This is likely because dogs recognise each other by smelling each other's behind and marking bushes with their urine[768].

The mind does not exist without a host, a brain. Only a living body with a functioning brain has a mind. Everything going through your mind - every thought, feeling, and sensation - is private to you and cannot be sensed by anyone else (unless you choose to share it). At this moment, we cannot literally read others' minds. Thus, the mind is an emergent property of the brain. Since the mind cannot be extracted or measured, it is an immaterial entity[769]. Yet, just as breathing or beating of a heart occurs, thoughts in your mind will continuously happen as long as you are alive.

Damage to the brain can produce a variety of mind disorders, transforming a pleasant person into a nasty one. There are examples of this in literature as we discussed the story of Mr Gage in Chapter

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[766] https://www.ninds.nih.gov/health-information/public-education/brain-basics/brain-basics-understanding-sleep
[767] Animal minds - The Economist https://www.economist.com/news/essays/21676961-i
[768] https://www.brittanica.com/video/187069/dogs-each-other/
[769] https://authortomharper.com/2019/06/13/is-the-mind-immaterial-or-material/

VII. 10). The abnormalities attributed to the mind are consequences of malfunctioning chemical processes in the brain. When the brain is partially or completely damaged as the result of sickness or accident, it affects the behaviour, cognitive, emotive and other functions of the person[770].

The mind operates at two levels: conscious and subconscious (excluding the unconscious state, which occurs when the brain loses connection with both the conscious and subconscious). When you are unconscious, you disconnect from your past and present thoughts, actions, and memories. The unconscious mind loses control over most bodily functions, although the heart may continue beating and the lungs breathing. Fainting and being sedated before surgery are two examples of the unconscious state.

Consciousness is the state of mind when we are aware of our thoughts and actions. In this state, you are in command and can readily acknowledge your feelings and cognition[771].

The subconscious mind operates beyond conscious awareness, influencing thoughts, feelings, and behaviour. It plays a role in memory, habits, beliefs, and emotions. The subconscious can be accessed through techniques such as hypnosis, meditation, and psychoanalysis.

The subconscious state of mind encompasses the reactions and actions we only realise upon reflection. Most of our thinking efforts occur subconsciously[772]. The subconscious mind is a secondary system which regulates everything in our lives, acting as a filter to prevent sensory overload from our environment. The "gut instinct" which guides our decisions, is an example of a subconscious behaviour, as is resistance to change.

Whilst the brain is a tangible system made of cells converting inputs to outputs, the mind is an intangible entity created by the workings of brain cells. Although the brain is located in our head, the mind cannot be localised to a specific area within the brain. Instead, it involves the entire cerebral cortex and deep grey matter. All mind-related activities, including consciousness, perception, reasoning, behaviour, intelligence, motivation, feelings, and desires, result from the extensive and complex neural linkages between different parts of the brain.

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[770] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3115284/ In 1848 in an unfortunate workplace accident, a metal rod pierced Mr Phineas Gage's left cheekbone and the frontal lobe of his brain. The rod came out from the top of his skull, and he survived. However, the accident changed his personality: Mr Gage went from being a pleasant, extremely nice person to become an irritating, vulgar, uncontrollable, irresponsible, profane, and abusive alcoholic.

[771] https://diversity.social/unconscious-vs-subconscious

[772] https://www.scientificamerican.com/article/can-we-control-our-thoughts/

X.6. WHAT IS MEMORY?

Memory is defined as the faculty of the mind by which data or information is encoded, stored, and retrieved when needed[773]. It involves the retention of information over time to influence future actions. The study of memory is a very important area of neuroscience. It is possible that consciousness is related to the access and application of stored memories, and the abstract patterns generated by them.

The brain and the mind are closely associated with memory. Specific areas of the brain involved in different types of memory include the hippocampus, amygdala, striatum, and mammillary bodies[774]. The amygdala is involved in emotional memories, while the cerebellum and basal ganglia are involved in procedural memories, such as the ability to ride a bike or tie shoelaces, and motor learning[775]. Among these, the hippocampus, a multi-tasker, is the most important.

The hippocampus functions as the GPS of the body, enabling you to navigate and remember facts. Located within the temporal lobes of the brain, the hippocampus is crucial for memory storage. There are two hippocampi, which draw memories from the cerebral cortex. The right hippocampus processes spatial cognition - the ability to recognise, create, and manipulate things around you, giving them meaning. It is the creative side, associating information with the senses and creating scenarios. The left hippocampus, on the other hand, is responsible for simple memory recall, such as names of places and people. This is the recall side, retaining the nomenclature of information. Damage to these areas of the brain can result in memory loss[776].

When an event occurs or when you observe something, your brain, facilitated by the hippocampi, automatically stores this experience as a memory. The accompanying audio-visual aspects of the event are stored based on the impact on your senses. If the event had little effect on you or if you did not pay much attention to it, it may be easily forgotten and deleted from your memory (op. cit.).

Stress has a significant impact on memory formation and learning. Under stressful situations, the brain releases hormones and neurotransmitters such as glucocorticoids and catecholamines, which affect the processes of memory encoding in the hippocampus. Chronic stress can lead to the

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[773] Sherwood L (1 January 2015). *Human Physiology: From Cells to Systems*. Cengage Learning. pp. 157–162. ISBN 978-1-305-44551-2.

[774] LaBar KS, Cabeza R (January 2006). "Cognitive neuroscience of emotional memory". *Nature Reviews. Neuroscience*. 7 (1): 54–64. doi :10.1038/nrn1825. PMID 16371950. S2CID 1829420.

[775] Doyon J, Bellec P, Amsel R, Penhune V, Monchi O, Carrier J, et al. (April 2009). "Contributions of the basal ganglia and functionally related brain structures to motor learning". *Behavioural Brain Research*. 199 (1): 61–75. doi :10.1016/j.bbr.2008.11.012. PMID 19061920. S2CID 7282686

[776] http://www.actforlibraries.org/how-does-the-brain-store-information/

production of adrenal hormones that influence the structure of the hippocampus in the brains of rats[777].

Glucocorticoids released during stress can damage neurons in the hippocampus, particularly in the Cornu Ammonis area (CA1). This damage occurs by reducing glucose release and glutamate reuptake. Elevated extracellular glutamate levels allow calcium to enter N-methyl-D-aspartate (NMDA) receptors, leading to neuronal cell death.

Once information is stored, it must be maintained as a memory. Research on animals suggests that working memory, which holds information for about 20 seconds, is sustained by an electrical signal looping through a specific sequence of neurons temporarily. Long-term memory, on the other hand, is believed to be maintained by structural changes involving certain types of proteins[778]. These proteins play a crucial role in the encoding and storage of memories that persist over extended periods of time.

There are several models which attempt to explain how knowledge (information) is organised in the brain [(op. cit.)]. The semantic network model proposes that concepts are represented as nodes, with connections based on their relatedness or association. For example, in a semantic network, "chair" might be linked to "table," which in turn could be linked to "wooden," and so on.

In contrast, the connectionist model suggests that knowledge is represented by patterns of neuronal activation rather than by explicit meaning. This model emphasises the distributed nature of information processing in the brain.

There is no universally accepted theory knowledge organisation at this time. Each model has its strengths and weaknesses, reflecting different aspects of how the brain processes and stores information.

The prevailing understanding is that a memory is a network of interconnected elements in the brain. For instance, if you witnessed a fatal traffic accident, different aspects of the event – the location, the emotions of the victims, the flashing lights of the police car - are encoded in various regions of the brain. When recalling this tragic event, neurons in these different areas are activated simultaneously. This activation spreads throughout the associated network of neurons,[779] resulting in retrieval of the memory.

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[777] Conrad CD (June 2010). "A critical review of chronic stress effects on spatial learning and memory". *Progress in Neuro-Psychopharmacology & Biological Psychiatry*. 34 (5): 742–55. doi :10.1016/j.pnpbp.2009.11.003. PMID 19903505. S2CID 41414240.

[778] https://www.teach-nology.com/teachers/methods/info_processing/

[779] https://en.wikipedia.org/wiki/Hebbian_theory

The phenomenon where neurons fire and wire together is described by Hebb's rule. According to this rule, the simultaneous activation of cells strengthens the synaptic connections between them, enhancing the network's ability to recall and store memories.

Sleep affects memory consolidation by strengthening neural connections in the brain, which enhances the stability and retention of memories[780].

Once memories are stored, retrieving them is not like replaying a video. Rather, it involves a process of reconstructing what might have happened based on stored details that the brain can recall. Recall is triggered by a retrieval cue, an environmental stimulus which prompts the brain to retrieve the memory[781]. Research indicates that the effectiveness of the retrieval cue correlates with the likelihood of successfully recalling the memory. It is important to note that retrieval cues can also lead to false memories, where a person reconstructs a memory inaccurately [op. cit.]. This underscores the complex nature of memory retrieval and the influence of external stimuli on the accuracy of recalled memories.

Recent technological developments have enabled detailed investigation of the human brain. It is now possible to record neuron activities in specific brain regions in response to stimuli - for example, sound activating the auditory cortex. Despite these developments, the electrochemical mechanisms of memory, particularly how information is stored, retained, and recalled, remain largely unknown.

Techniques such as magnetic resonance imaging (MRI) have allowed researchers to study the brain in action as individuals perform tasks. This assists in identifying which brain regions are important for specific activities. Currently we understand that when neurons receive signals, such as from the eyes, their electrical charge briefly changes. If this change is strong enough, it can trigger the release of chemicals which signal to connected neurons[782]. We now recognise that information can be encoded in networks of neurons through various mechanisms.

Recently, a new technique has been developed to monitor individual brain cell's activities[783]. A study led by Zandonella (2012)[784] published in the journal *Nature*, explored how neurons encode

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[780] https://en.wikipedia.org/wiki/Memory

[781] https://www.teach-nology.com/teachers/methods/info_processing/

[782] https://sitn.hms.harvard.edu/flash/2012/issue124a/

[783] https://en.wikipedia.org/wiki/Memory

[784] Zandonella, Catherine. (2012). Princeton scientists identify neural activity sequences that help form memory, decision-making. http://www.princeton.edu/main/news/archive/S33/17/36M20/index.xml?section=topstories
Harvey, Christopher et al. Choice-specific sequences in the parietal cortex during a virtual-navigation decision task. Nature, v. 484: 62-68 (5 April 2012).

memories in mice. This innovative imaging method allowed researchers to observe individual brain cells while the mice performed behavioural tasks.

The study revealed that when a neuron is activated, nuclear pores on its surface open,[785] allowing electrically charged[786] calcium atoms flow into the cell. This influx of calcium triggers the release of chemicals which enable the neuron to communicate with neighbouring cells. To precisely track the activation of individual cells – including their location, timing, and duration - scientists inserted a special gene into the mice. This gene encodes a protein which causes cells to "light up" in the presence of calcium"[787].

In hippocampal neurons specifically, the release of calcium triggers the production of new proteins which strengthen synapse connections. This process is dependent on the expulsion of magnesium from the cells. These findings provide valuable insights into the mechanisms underlying memory formation and synaptic plasticity in the brain.

Other recent research[788] has revealed that long-term memory formation relies on the activation of memory-promoting genes and the inhibition of memory-suppressor genes. By 2015, it was evident that establishing long-term memories involves activating gene transcription and synthesising new proteins, including those which suppress memories. A significant mechanism identified for this dual regulation is DNA methylation and demethylation. These processes are vital in controlling gene expression related to memory formation.

Technological advancements now enable real-time study of brain activities. Thus far, complete connectomes – detailed brain wiring diagrams - have been mapped only for simpler organisms with several hundred neurons, such as the nematode *C. elegans*, the sea squirt *Ciona intestinalis* larva, and the marine annelid *Platynereis dumerilii*.

In a recent breakthrough, Winding et al. (2023)[789] generated a three-dimensional wiring diagram of the brain of a small insect *Drosophila melanogaster* using electron microscopy imaging. They mapped the complete synaptic-resolution connectome of this insect's brain, revealing 3016 neurons and 548,000 synapses. Their study characterised the intricate brain organisation, different

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[785] Cells have pores on their surface called nuclear membrane pores. These pores contain proteins that control and facilitate the movement of molecules into and out of the nucleus.

[786] An atom becomes electrically charged when the number of electrons or protons stops being equal. This imbalance makes the electrically charged atom get attracted to the protons or electrons in other atoms. Atoms are normally in a neutral state.

[787] https://sitn.hms.harvard.edu/flash/2012/issue124a/

[788] Oliveira AM (October 2016). "DNA methylation: a permissive mark in memory formation and maintenance". *Learn Mem*. 23 (10): 587–93. doi:10.1101/lm.042739.116. PMC 5026210. PMID 27634149.

[789] Michael Winding et al., 2023. The connectome of an insect brain. Science, Vol 379, Issue 6636; https://www.science.org/doi/10.1126/science.add9330

neuron types, hubs, feed-forward and feedback pathways, as well as interactions between brain hemispheres and the nerve cord.

The N-methyl-D-aspartate receptor (NMDAR) is the predominant molecular device in the brain which regulates episodic and spatial memories, as well as synaptic plasticity[790]. It functions as a major excitatory ligand-gated ion channel in the central nervous system. When activated, NMDARs depend on two simultaneous events: the binding of its natural ligand, glutamate, and depolarization of the neuron, which removes magnesium ions blocking the ion-channel pore. Blocking NMDARs in the brain of mice has been shown to impair synaptic plasticity and compromise learning and memory. Conversely, enhancing NMDAR function genetically has been found to improve memory in adult mice.

Refer to Li and Tsien (2009)[791] in N Engl J Med for biochemical workings of the brain and memory. As well, detailed information about diverse factors influence memory formation can be found in literature and as a starter in the Wikipedia link in footnote[792].

Types of memory

There are several different types of memory (op.cit.). Each is summarised briefly below:

Short-term memory does not have a large capacity. It characteristically only holds information for seconds or minutes, and allows recall for a period of several seconds to a minute without rehearsal. Its limited capacity is attributed to weak synaptic strength between neurons.

Long-term memories can be recalled days or years after the event. They represent strong neural connections. Important milestones like the day you graduated, got married or divorced, or the birth of your child, are examples of long-term memories.

Intermediate-term memory is the bridge between short-term and long-term memory, according to Kaminski (2017)[793] . It involves the translation of mRNA transcripts already present in neurons,[794] and the activation of proteins kinase A and kinase C. It is thought to be supported by the parahippocampal cortex. This type of memory fades away completely before the onset of long-term memory.

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[790] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3703758/

[791] Fei Li, and Joe Z. Tsien, 2009. Memory and the NMDA Receptors. N Engl. J Med. 2009 Jul 16; 361(3): 302–303. Doi: 10.1056/NEJMcibr0902052, PMCID: PMC3703758, NIHMSID: NIHMS228498, PMID: 19605837

[792] https://en.wikipedia.org/wiki/Memory

[793] Kamiński J (May 2017). "Intermediate-Term Memory as a Bridge between Working and Long-Term Memory". *The Journal of Neuroscience*. 37 (20): 5045–5047. doi:10.1523/JNEUROSCI.0604-17.2017. PMC 6596466. PMID 28515306.

[794] https://en.wikipedia.org/wiki/Intermediate-term_memory

Involuntary memory is a sub-component of memory which occurs when cues encountered in everyday life evoke recollections of the past without conscious effort. It is the opposite of voluntary memory, which is characterised by a deliberate effort to recall the past. Involuntary memories may sometimes trick you, for example if you regularly take the escalator at your shopping centre, your brain learns the ride and this knowledge becomes an involuntary memory after a few rides. However, one day when the escalator breaks down and you must walk on it as if it was a flight of stairs, the brain gets confused because the sensation of walking on the escalator does not match the usual experience of the ride which is stored in the brain.

Photographic memory is the ability to recall things from memory with high precision, after only seeing it once for a very brief period. People with this type of memory are very rare.

Working memory encompasses reasoning and the ability to guide decision-making and behaviour. It involves maintaining neural circuits which encode remembered items in an active state. This process is akin to mentally rehearsing items on a shopping list, ensuring you remember what you need to buy. The distinction between working memory and short-term memory lies in the ability of working memory to manipulate stored information. While short-term memory focuses on temporarily holding information[795], working memory allows for the active manipulation and processing of this information to guide ongoing tasks and decisions.

False memory is a phenomenon where individuals recall events which did not really occur, or recall them inaccurately compared to how they actually happened. These memories can be created through misinformation or misattribution. Sleep deprivation has been linked to an increased susceptibility to forming false memories. In some cases, false memories can be widespread, with a large number of people believing that an event occurred when it did not. For example, there was a widespread false belief that Nelson Mandela died in prison in 1980, whereas he actually died in 2013. Such instances illustrate how collective misinformation or rumours can lead to the formation of false memories on a larger scale.

Implicit memory refers to the retention of information without conscious effort or awareness. It is often referred to as unconscious or unintentional memory[796]. With implicit memory, individuals can perform tasks or exhibit behaviours based on past experiences without actively recalling those experiences. In contrast, explicit memory involves conscious awareness and the ability to verbally recall and explain past experiences. Explicit memories are consciously retrieved and articulated, while implicit memories typically operate non-consciously and are not easily verbalised (op. cit.).

[795] Mariano Sigman, https://www.quora.com/ How-are-memories-stored-and-retrieved-in-the-human-brain
[796] https://www.verywellmind.com/implicit-and-explicit-memory-2795346

Muscle memory is like implicit memory but more physical-based rather than recollection of information. Muscles have the ability of retaining and recalling specific movements or actions through repetitive practice. However, the memory is not actually stored in the muscles but rather in the brain, particularly in the motor cortex. Muscle memory allows us to perform complex movements with less conscious effort, as the brain can quickly recall and execute the learned sequence of muscle contractions and relaxations.

When we repeatedly perform a physical task, such as playing a musical instrument, typing on a keyboard, or performing a sport, our brain forms strong neural connections associated with that movement pattern. These connections, involving the motor neurons and pathways, become more efficient with practice, making the movement smoother and more automatic over time.

Sensory memory briefly holds information received from the five senses - vision, hearing, taste, smell, and touch – for less than one second after perception. Sensory receptors continuously gather information which is then processed by the nervous system. This information remains briefly in sensory memory before being transferred to short-term memory for further processing and storage. Sensory memory retains information for less than a minute, allowing for immediate tasks and decisions. Long-term memory, on the other hand, persists from thirty minutes to a lifetime, enabling the retention of significant life events and learned knowledge. Intermediate-term memory spans about two to three hours, providing a bridge between short-term and long-term memory for temporary retention of information.

Memories naturally fade over time, particularly as we age, but there are strategies to help maintain and enhance memory capacity. One effective technique is chunking, which involves grouping information into smaller, more manageable chunks. For instance, remembering a ten-digit bank account number or telephone number by breaking it into familiar segments, such as the area code (such as 03 for Melbourne), followed by smaller groups of digits in two small chunks (9354 and 2120). This method can significantly aid recall because our brains process and retain information more effectively when it is chunked into meaningful units.

Another method is actively engaging in the memory process to “save” memorable sensations or events before they diminish. This involves paying genuine attention to experiences, mentally revisiting or visualising them several times, and using associative recall techniques. Associating new information with familiar concepts or personal experiences helps in retaining memories more

effectively. This associative method is also utilised by some individuals who can accurately predict the next card to be drawn from a deck through memorisation techniques[797].

Memory is a gift, but not one specifically given just to humans. We know that elephants, dolphins, chimpanzees, ravens, magpies, and crows can remember people even years after having met them. Crows, magpies and ravens also make and use tools - a marker for intelligence. Additionally, they have the ability to adapt to changing circumstances, care for and teach their young, and sense changes in their surroundings, responding appropriately[798].

Honeybees remember the location of flowers with sweet nectar, and squirrels know where they stashed their nuts[799]. After a single learning trial, a free-flying honeybee remembers the location of nectar for only a day or two[800] . By three learning trials, it will remember the location for a lifetime[801]. Slugs *Limax flavus* have a short-term memory of approximately one minute and long-term memory of one month[802].

Action potentials, a physiological response characteristic of neurons and neurotransmitters, have been shown to influence plants (op. cit.). Additionally, plants have also been observed to encode, store, and retrieve basic short-term memories[803].

Research has shown that certain plants, like the *Venus flytrap* and *Mimosa pudica (the Shy plant)*, exhibit memory-like behaviours despite lacking a central nervous system or brain[804]. These plants can respond to stimuli and store information related to their environment.

The *Venus flytrap* can remember an initial stimulus long enough for a second stimulus to initiate trap closure. This memory is stored in the form of cytoplasmic calcium levels. The first trigger causes a sub-threshold cytoplasmic calcium influx[805]. However, it is not enough to activate trap closure. A second stimulus is needed for another influx of calcium, which added to the initial one,

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797 https://www.wikihow.com/Memorize-a-Deck-of-Cards

798 Are crows and magpies just as smart as ravens since they're from the same family of bird? Annie Walsh, a bird observer; Quora.com; April 19, 2019.

799 https://en.wikipedia.org/wiki/Animal_cognition

800 A honey bee lives normally for up to two months.

801 Hammer M, Menzel R (March 1995). "Learning and memory in the honeybee". *The Journal of Neuroscience*. 15 (3 Pt 1): 1617–30. doi:10.1523/JNEUROSCI.15-03-01617.1995. PMC 6578179. PMID 7891123

802 Yamada A, Sekiguchi T, Suzuki H, Mizukami A (March 1992). "Behavioral analysis of internal memory states using cooling-induced retrograde amnesia in Limax flavus". *The Journal of Neuroscience*. 12 (3): 729–35. doi:10.1523/JNEUROSCI.12-03-00729.1992. PMC 6576046. PMID 1545237

803 https://en.wikipedia.org/wiki/Memory

804 Baluska F, Mancuso S (February 2009). "Plant neurobiology: from sensory biology, via plant communication, to social plant behavior." *Cognitive Processing*. 10 (Suppl 1): S3-7. doi:10.1007/s10339-008-0239-6. PMID 18998182. S2CID 9880214

805 Hedrich R, Neher E (March 2018). "Venus Flytrap: How an Excitable, Carnivorous Plant Works". Trends in Plant Science. 23 (3): 220–234. doi :10.1016/j.tplants.2017.12.004. PMID 29336976.

creates an action potential which exceeds the threshold, thus resulting in trap closure[806]. After trap closure, electrical signals stimulate glandular production of jasmonic acid ([(1*R*,2*R*)-3-Oxo-2-[(2*Z*)-pent-2-en-1-yl]cyclopentyl]acetic acid) and the enzyme hydrolases, which allows the plant to digest its prey[807].

Similarly, *Mimosa pudica* can remember tactile stimuli which cause its leaves to fold up when touched. After repeated touching, the plant learns to respond more quickly to subsequent stimuli, suggesting a form of short-term memory.

These memory-like responses in plants are thought to involve changes in ion fluxes, hormone levels, and gene expression patterns, rather than neural activity as in animals. While not equivalent to the complex memory systems found in animals, these plant behaviours demonstrate that living organisms can exhibit adaptive responses to their environment through mechanisms that somewhat resemble memory processes.

X.7. How Does The Brain Make Decisions? [808]

Decision making is an inseparable part of our everyday life when we have an active brain. Although we attribute decisions to individuals, it is actually the brain which makes these choices. Decision making involves identifying and selecting a particular option among a set of alternatives, and assessing the impact of that choice to determine whether it will produce a positive (good) or negative (bad) outcome. Our brains make hundreds, if not thousands, of decisions everyday, aiming to find the best or most optimal choice for a given situation.

From the moment we wake up until we fall asleep, our decision-making varies from simple choices like 'Shall I take a bus or drive a car?,' 'Coffee or tea?' or 'Coffee with milk or without?' to more complex and abstract considerations like 'Did God create us, or did we create God? We can make right or wrong decisions, poor decisions, or struggle to decide. Every decision we make has consequences, whether immediate or in the future, and these consequences can range from unpleasant or catastrophic, to happy or neutral.

Numerous phenomena are involved in decision making, including cognitive biases, reasoning, evaluating, remembering past rewards and penalties, other factors like social norms, peer pressure,

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[806] Volkov AG, Carrell H, Baldwin A, Markin VS (June 2009). "Electrical memory in Venus flytrap". Bioelectrochemistry. 75 (2): 142–147. doi:10.1016/j.bioelechem.2009.03.005. PMID 19356999.

[807] Stokstad E (May 2016). "PLANT SCIENCE. How the Venus flytrap acquired its taste for meat". Science. 352 (6287): 756. Bibcode: 2016Sci...352..756S . doi:10.1126/science.352.6287.756. PMID 27174967.

[808] Peter R. Murphy et al., Adaptive circuit dynamics across human cortex during evidence accumulation in changing environments. *Nature Neuroscience*(2021). DOI: 10.1038/s41593-021-00839-z; Ingrid Fadelli , Medical Xpress, June 21, 2021 New insight into how the brain makes decisions in changing environments; https://medicalxpress.com/news/2021-06-insight-brain-decisions environments.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter .

upbringing, health, personality, mood, and even the weather. Being outside in 40–50-degree Celsius temperatures for a prolonged time can be taxing on the body and strenuous for the brain.

Making the right decision requires a healthy brain. Decision making can be impaired by several factors, including debilitating mental illnesses such as schizophrenia, Parkinson's disease, and autism.

Decisions are made explicitly when one consciously combines beliefs and values to choose a course of action. They are made implicitly when one relies on ritualised responses, such as habits, traditions, or superstitions, to cope with choices between options[809]. Decisions can be rationally, non-rational, or irrational[810].

Rational decisions are made consciously and analytically, assessing risks based on facts and figures rather than emotions and intuitions. In rational decision-making, only the probabilities and utilities of different outcomes are considered, and negative outcomes are weighed.

Non-rational decisions are typically made rapidly, often too quickly for a thorough analysis of the situation. These decisions may rely on intuitive judgement and previous experiences.

Irrational decisions are made hastily, without considering outcomes or logical reasoning. While rational and non-rational decisions are based on common sense, irrational decisions are not.

The brain oversees all our bodily functions, and processes information received from both external and internal sources. It also manages our emotions and cognitive abilities, including thoughts, long- and short-term memories, and decision-making[811].

Decision-making is a complex, multidimensional process involving many (if not all) sectors of the brain. Multiple algorithms and brain systems work together a flexible and combined manner[812]. The primary region involved in decision-making is the ventromedial prefrontal cortex, which integrates sensory, mnesic (memory-related), and emotional information relevant to the task.

Other structures involved in the various processes of decision making include the amygdala and the cingulate cortex, which are crucial for monitoring and response inhibition, particularly in situations

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809 https://nap.nationalacademies.org/read/759/chapter/3

810 Jesus Gil Hernandez, Rational, Nonrational and Irrational Decision Making. https://jesusgilhernandez.com/2014/03/31/rational-nonrational-and-irrational-decision-making/

811 https://www.medicalnewstoday.com/articles

812 Daeyeol Lee. Decision Making: from Neuroscience to Psychiatry. Neuron. 2013 Apr 24; 78(2): 233–248. doi: 10.1016/j.neuron.2013.04.008 PMCID: PMC3670825 NIHMSID: NIHMS470473 PMID: 23622061. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3670825/

of uncertainty[813]. The cortical structures involved in decision-making include the orbitofrontal cortex, anterior cingulate cortex, and dorsolateral prefrontal cortex. This process is supported by subcortical structures, such as the amygdala, thalamus, and cerebellum[814]. The prefrontal dorsolateral cortex is also involved, particularly through the activation of working memory, especially in complex tasks[815].

Several studies using neuro-imaging[816] and single-neuron recording methods have shown that the amygdala is involved in decision-making. The amygdala processes and encodes emotional signals and their association with contextual stimuli, making it the integrative centre for emotions, emotional behaviour, and motivation[817].

The amygdala receives inputs from all senses as well as instinctive inputs, and the fibres carrying inputs to the amygdala are almost always combined with fibres carrying outputs from it. The activity in the amygdala changes depending on whether a particular outcome will be a gain or a loss. This is evident because loss aversion is abolished in patients with an impaired amygdala[818]. Stimulation of the amygdala can cause intense emotions, such as aggression or fear.

It is well known that the decision-making process results from communication between the prefrontal cortex (working memory) and the hippocampus (long-term memory)[819]. However, other regions of the brain also play essential roles in making decisions. Besides the dorsolateral prefrontal cortex and amygdala, these include the anterior cingulate cortex, ventromedial prefrontal cortex, ventral striatum, and insula[820].

The largest lobe of the brain, the frontal lobe, is located just inside the forehead and is involved in personality characteristics, decision-making, and movement. Damage to the frontal lobe can impair one's ability to plan, think and make choices or decisions[821]. The prefrontal cortex, situated

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[813] Anthony Wright ,Chapter 6: Limbic System: Amygdala, 10 Oct 2020. https://nba.uth.tmc.edu/neuroscience/m/s4/chapter06.html ;

[814] https://www.sciencedirect.com/science/article/pii/S2173580816300311

[815] https://pubmed.ncbi.nlm.nih.gov/16602058/

[816] The neuro-imaging technique for mapping brain activity involves recording magnetic fields produced by electrical currents occurring naturally in the brain, using very sensitive magnetometers.

[817] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7149951/

[818] Anzhelika Engel and Ricardo Cáceda. 2015 Can Decision Making Research Provide a Better Understanding of Chemical and Behavioural Addictions? *Current Drug Abuse Reviews*, *8,* 000-000 11874-4737/15 Bentham Science Publishers

[819] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7149951/

[820] Anzhelika Engel and Ricardo Cáceda. 2015 Can Decision Making Research Provide a Better Understanding of Chemical and Behavioural Addictions? *Current Drug Abuse Reviews*, *8,* 000-000 11874-4737/15 Bentham Science Publishers

[821] https://www.rte.ie/brainstorm/2019/1122/1094470-decision-making/

immediately behind the forehead, serves as the control centre for our highest cognitive abilities, including concentration, insight, judgement, and memory retrieval[822].

The amygdala integrates various different sensory inputs. Like the hippocampus it combines external and internal stimuli. Every sensory modality has input. These are integrated with somatosensory (sensation such as pressure, pain, or warmth which can occur anywhere in the body) and visceral (instinctive or gut feeling) inputs. The link between prefrontal cortex, septal area (a region of the forebrain), hypothalamus, and amygdala likely gives us our gut feelings, those subjective feelings, about what is good and what is bad. Emotion in the amygdala is linked with perception in the inferior part of the temporal cortex to create an intense emotionally charged memory.

Destructive lesions of the amygdala cause tameness in animals, and a placid calmness in humans. Schizophrenic patients who are aggressively violent or emotionally agitated become calm by severing some communication *lines* of the amygdala.

Weighing reward against risk is one of the most important factors in decision making. The value of a reward can be influenced by the physiologic state of the individual (such as sleep deprivation, hunger, or thirst) and the present circumstances. Neuro-imaging experiments have identified dopamine-rich regions that seem to encode rewarding.

Like reward processing, emotions play a critical role in the ability to make fast, rational decisions especially in complex and uncertain situations. Strong emotions and other stimuli induce a somatic or physiological signal in the brain. When making decisions, these physiological signals and their evoked emotions are consciously or unconsciously associated with their past outcomes and bias decision-making towards certain behaviours while avoiding others. Both the ventromedial prefrontal cortex and amygdala are critical to triggering somatic states where amygdala is responsible for processing events in the immediate environment, while the ventromedial prefrontal cortex triggers somatic states from memories, knowledge, and cognition[823].

A study by a team of the SALK Institute of Biological Studies (2017)[824] showed that dopamine, more specifically nigrostriatal dopamine, plays an important role in decision-making. Their experiments with mice indicated that dopamine directs behavioural choices. They demonstrated that when mice

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[822] https://www.ncbi.nlm.nih.gov/articles/PMC4774859

[823] Anzhelika Engel and Ricardo Cáceda. 2015 Can Decision Making Research Provide a Better Understanding of Chemical and Behavioural Addictions? *Current Drug Abuse Reviews*, *8,* 000-000 11874-4737/15 Bentham Science Publishers

[824] Christopher D. Howard, Hao Li, Claire E. Geddes, and Xin Jin. 2017. Dynamic nigrostriatal dopamine biases action selection . *Neuroscience.* Volume 93, ISSUE 6, P1436-1450.e8. DOI:https://doi.org/10.1016/j.neuron.2017.02.029 ; https://www.cell.com/action/showPdf?pii=S0896-6273%2817%2930137-X

switched actions, changes in the firing rate of nigrostriatal dopamine neurons, as well as dopamine signalling in the dorsal striatum, were associated with decision-making.

The SALK Team also found that genetic deletion of N-methyl-D-aspartate receptors on dopamine or striatal neurons, or optogenetic manipulation of dopamine concentration, alters dopamine signalling and biases decision-making.

Time is also a critical factor in decision-making. According to researchers[825], the brain prepares to act up to ten seconds before you are consciously aware of it. By examining brain activity during the decision-making process, researchers could predict people's choices before they were consciously aware of having decided. There are just a few milliseconds between when a thought becomes conscious and when it is enacted[826], providing a brief window to consciously reject unconscious impulses.

X.8. Consciousness and the Brain

Consciousness arises from the brain and body working together. It is simply the awareness of being alive and the perception that you and everything around you exist, according to René Descartes' famous phrase, "*I think therefore I am*." When conscious, you possess self-awareness and can interact with the world[827].

According to Lee Strobel[828] , as the brain reaches a certain level of complexity, consciousness emerges, bringing feelings, self-awareness, subjectivity, hopes, a point of view, and introspection.

Attention, self-awareness, access to information, and communication skills are integral to consciousness.

Consciousness requires being alive: once deceased, consciousness ceases. Brain damage, from traumatic injuries like falls, accidents, or strokes, can impair consciousness temporarily or permanently, such as in coma cases. Unlike the body, the brain does not heal itself[829] because the intricate wiring of the brain is far too complex. For instance, oxytocin receptors are dispersed

825 https://www.nature.com/articles/news.2008.751

826 https://qz.com/1569158/neuroscientists-read-unconscious-brain-activity-to-predict-decisions/

827 https://theconversation.com/consciousness-how-the-brain-chemical-dopamine-plays-a-key-role-new-research-165498

828 Lee Strobel, 2004. The Case for a Creator. Printed by Zondervan, USA, 341 p. THE MYSTERY OF THE MIND. A Critical Study of Consciousness and the Human Brain. Wilder Penfield. 123 pp. Illust. Princeton University Press, Princeton, NJ, 1975.

829 https://www.healthline.com/health/brain-damage

across several brain regions like the periaqueductal grey, putamen, insula, amygdala, nucleus accumbens[830] (linking motivation and action), and the prefrontal cortex[831].

For a long time, people have wondered how biological mechanisms could lead to the experience of being alive. In the past, people believed that the essence of being alive could not be explained through physics and chemistry alone. They proposed mystical explanations such as a life force, élan vital or vital essence, and a creator God. However, as biologists began to explain the characteristics of living organisms using biological, chemical, and neurological terms, this initial sense of mystery surrounding transformed.

They helped us understand that life comprises a variety of interconnected yet distinct processes, including metabolism, homeostasis[832], and reproduction[833]. They demonstrated that consciousness emerges from the electrochemical networks within our brains, where billions of neurons act as individual biological machines communicating with one another.

When certain parts of your brain cease to communicate, you are likely to experience unconsciousness. This state can result from disruptions in the brain's electrochemical circuitry due to natural causes, trauma, fainting, or induced by anaesthesia. Anaesthetic drugs alter the brain's oscillation patterns, preventing neurons from effectively communicating across different regions. This induces a state known as a "reversible coma," distinct from ordinary sleep. While in a coma, individuals exhibit minimal brain activity and cannot be awakened through physical or auditory stimulation, showing no awareness of their surroundings[834]. General anaesthesia similarly modifies consciousness temporarily, without globally shutting down brain function[835]. Various anaesthetic agents like benzodiazepines, diazepam, ketamine, and propofol, exert specific and dose-dependent effects on brain activity. Among those, ketamine ($C_{13}H_{16}Cl_2NO$) is a hallucinogenic drug, like LSD (lysergic acid diethylamide, $C_{20}H_{25}N_3$), PCP (phencyclidine, $C_{17}H_{25}N$), and mescaline (a phenethylamine alkaloid). It distorts perceptions of sight and sound, making the user feel disconnected and out of control. Ketamine is used as a short-acting anesthetic for both humans and animals. It causes patients to feel detached from their pain and environment. A person under the

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[830] The nucleus accumbens is considered as the neural interface between motivation and action, playing a key role on feeding, sexual, reward, stress-related, drug self-administration behaviors, etc. https://pubmed.ncbi.nlm.nih.gov/10870199/

[831] https://www.health.harvard.edu/mind-and-mood/oxytocin-the-love-hormone

[832] Homeostasis means adjusting to external challenges to survive

[833] YOUR BRAIN HALLUCINATES YOUR CONSCIOUS REALITY BY ANIL SETH HTTPS://WWW.YOUTUBE.COM/WATCH?V=LYU7V7NWZFO

[834] https://brainfoundation.org.au/disorders/coma

[835] Vincent Bonhomme et al., 2019. General Anesthesia: A Probe to Explore Consciousness. Front. Syst. Neurosci., 14 August 2019, Volume 13 - 2019 | https://doi.org/10.3389/fnsys.2019.00036; https://www.frontiersin.org/articles/10.3389/fnsys.2019.00036/full

influence of ketamine feels calm and relaxed, relieved from pain, and may have no memory of events. Overuse and overdose of the drug led to the death of Mathew Perry, the star of the sitcom Friends.

Colonnello and Heinrichsm (2016)[836] have identified three interdependent levels of self-consciousness: anoetic, noetic, and autonoetic. Each is briefly described below:

Anoetic (unknowing) consciousness arises without the cognitive self-observation of one's actions. It involves a direct, sensorial-perceptual experience of both the world and oneself, constituting a fundamental aspect of first-person phenomenal self-experience[837]. This state is believed to engage the basal sub-cortical system, spanning from the brainstem to the hypothalamus and central thalamic nuclei.

Noetic (knowing) learning-based consciousness involves learning-based self-awareness and the recognition of oneself as "me". It is where one observes oneself as distinct from others. This state activates the lower subcortical ganglia and upper limbic cortical midline structures of the brain. Oxytocin administration is thought to influence noetic levels of self-consciousness and may have therapeutic effects on anxiety, cognitive processes, and reduced psychosocial stress[838].

The most complex level of self-consciousness is known as autonoetic (self-knowing). This involves meta-cognitive tasks such as reflecting on one's past and future experiences. It depends on associative neocortical brain areas[839]. Research suggests that the oxytocin system influences autonoetic self-consciousness by aiding in the recall of personal memories and positive social affiliations (op. cit.).

In his TED lecture,[840] Anil Seth describes how the brain interprets sensory information as streams of electrical impulses. These impulses are integrated with the brain's expectations and beliefs about the world, to form its best guess of reality. Seth suggests that our perception is not a direct reflection of external reality, but rather a constructed representation. He refers to this process as a controlled hallucination, where our experience of self and our environment has evolved over millions of years of evolution to keep us alive.

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836 Valentina Colonnello and Markus Heinrichsm 2016. Oxytocin and Self-Consciousness. Front. Hum. Neurosci., 29 February 2016, Sec. Cognitive Neuroscience. https://doi.org/10.3389/fnhum.2016.00067

837 https://www.frontiersin.org/articles/10.3389/fnhum.2016.00067/full

838 Flávia de Lima Osório et al, Effects of intranasal oxytocin on the self-perception and anxiety of singers during a simulated public singing performance: A randomized, placebo-controlled trial, *Frontiers in Neuroscience* (2022). DOI: 10.3389/fnins.2022.943578

839 Valentina Colonnello and Markus Heinrichsm 2016. Oxytocin and Self-Consciousness. Front. Hum. Neurosci., 29 February 2016, Sec. Cognitive Neuroscience. https://doi.org/10.3389/fnhum.2016.00067

840 Your brain hallucinates your conscious reality by Anil Seth https://www.youtube.com/watch?v=lyu7v7nWzfo

While different parts of the brain communicate with each other, a command centre exists which regulates the entire body's functioning. *"We don't just experience our bodies as objects in the world from the outside; we also experience them from within. We all experience the sense of being a body from the inside. And sensory signals coming from the inside of the body are continually telling the brain about the state of the internal organs, how the heart is doing, what the blood pressure is like, lots of things"* Anil Seth says.

Our most fundamental sense of self and embodiment as living organisms is rooted in these biological mechanisms essential for survival. Seth concludes saying that *"All of our conscious experiences, since they all depend on the same mechanisms of predictive perception, all stem from this basic drive to stay alive".* This perspective echoes Richard Dawkins' concept in *The Selfish Gene*.

Severe brain injuries can present in various forms. Conditions such as coma, vegetative states, or induced unconsciousness during surgery can profoundly affect consciousness. In cases of coma or vegetative states, where brain activity appears absent while the heart continues to function, patients are not clinically considered dead because there remains a potential for consciousness to return.

Interestingly, documented cases challenge initial assessments of unconsciousness. For instance, a 2006 study[841] involving a 23-year-old woman, following a severe brain injury from a traffic accident, was initially diagnosed as being in a vegetative state. However, function MRI (fMRI) scans revealed signs of awareness when she was asked to imagine activities like playing tennis and walking at home. The brain regions associated with these tasks showed activation patterns similar to those of a healthy individual. Other sources[842] suggest that up to one in five patients previously classified as being in a vegetative state or lacking brain activity might indeed possess consciousness and awareness of their surroundings.

Studies[843] investigating the brain regions responsible for human conscious experiences suggest that dopamine, the brain's pleasure or feel-good hormone, plays a significant role. Dopamine is active within a network of interconnected brain areas associated with self-awareness. Impairment of this network due to anaesthesia or brain damage can lead to short- or long-term consciousness disorders, highlighting the critical role of dopamine in consciousness.

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[841] https://theconversation.com/consciousness-how-the-brain-chemical-dopamine-plays-a-key-role-new-research-165498 Published: August 4, 2021 11.53pm AEST

[842] One in five patients in a vegetative state are really AWAKE and locked in unresponsive bodies, experts warn. https://www.dailymail.co.uk/news/article-9845353/Thousands-patients-thought-vegetative-state-really-awake-experts-warn.html

[843] https://www.pnas.org/doi/pdf/10.1073/pnas.2026289118 the Proceedings of the National Academies of Science

Clinical evidence from Friedman et al (2019)[844] supports this role, demonstrating impaired dopamine release in patients with consciousness disorders and in healthy individuals following anaesthesia. Several small-scale studies (op. cit.) have indicated that drugs acting on dopamine pathways can potentially improve patients' consciousness levels.

Recent studies[845] on the neuropeptide oxytocin revealed its role in modulating various aspects of self-consciousness. For instance,[846] oxytocin plays a central role in social cognition, enhancing skills such as mind-reading and understanding of others' perspectives. It also influences the evaluation of others' trustworthiness. The oxytocin system is associated with promoting social interaction, reducing stress levels, and stimulating processes related to restoration and growth[847]. Beyond its effects on social perceptions, oxytocin also impacts the processing of self-related information, influencing multiple levels of self-consciousness and their interrelationships.

Produced in the hypothalamus and released into the bloodstream by the pituitary gland, oxytocin is known as the "love hormone" due to its role in facilitating childbirth and bonding with loved ones. Its release can be triggered by activities such as touch, music, and exercise[848].

We often say humans have consciousness or sentience, while animals do not. Sentience and consciousness denote the ability to have subjective experiences, such as sensing and understanding the world around you, a level of self-awareness, and the capacity to feel joy or pain. For centuries, it was assumed that animals lacked consciousness. Even in the 17th century, the French philosopher René Descartes argued that animals were merely "material automata" - lacking souls or consciousness.

The general belief was that animals "can't feel or can't suffer," so to feel compassion or empathy for them was somewhat silly or snobbish. According to the Bible, "Gen. 1, Verses 26 to 31: 'And God said, Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.'" However, these beliefs have eventually changed as emerging scientific evidence has indicated that a surprising range of creatures, including reptiles,

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844 Esteban A Fridman et al., Presynaptic dopamine deficit in minimally conscious state patients following traumatic brain injuryBrain. 2019 Jul 1;142(7):1887-1893. doi: 10.1093/brain/awz118. https://pubmed.ncbi.nlm.nih.gov/31505542/ https://www.forbes.com/sites/quora/2016/04/19/how-does-the-human-brain-create-consciousness/?sh=185e9b4b661a

845 Valentina Colonnello and Markus Heinrichsm 2016. Oxytocin and Self-Consciousness. Front. Hum. Neurosci., 29 February 2016, Sec. Cognitive Neuroscience. https://doi.org/10.3389/fnhum.2016.00067; https://www.frontiersin.org/articles/10.3389/fnhum.2016.00067/full

846 https://www.frontiersin.org/articles/10.3389/fnhum.2016.00067/full

847 Inga D.Neuman, (2007). Oxytocin: The Neuropeptide of Love Reveals Some of Its Secrets. Cell Metabolism, Volume 5, Issue 4, Pages 231-233. https://doi.org/10.1016/j.cmet.2007.03.008; https://www.sciencedirect.com/science/article/pii/S1550413107000691

848 https://www.health.harvard.edu/mind-and-mood/oxytocin-the-love-hormone

insects, birds, mammals, a variety of fish like octopuses, cuttlefish, whales, and some crustaceans, possess consciousness.

This recent surge of findings was the result of applying new cognition tests to a wider range of species. One of those tests was to see if an animal can recognize itself in a mirror[849]. In this test, a cleaner wrasse (fish) was placed in a tank first without a mirror, to which it exhibited no unusual reaction. However, when a mirror was placed on top of the tank, seven out of ten fish launched attacks toward the mirror, signaling that they likely interpreted the image as a rival fish. Some appeared to spend a long time in front of the mirror trying to understand what was happening. After several days, most fish settled down but began to exhibit unusual behaviours in front of the mirror, such as swimming upside down, which had never been observed before. Most bizarre of all was when the researchers marked the fish with a brown splotch under the skin to resemble a parasite; some fish attempted to rub the mark off (op.cit).

Another interesting example for animal intelligence and conscious behaviour was reported by Sharma et al (2024)[850]. They found that sperm whales (*Physeter macrocephalus)* communicate with each other using sequences of clicking sounds called codas. Sharma et al (2024) explained the codas encode information that has rhythm and tempo, producing a large inventory of distinguishable sounds. They claimed that, "Sperm whale vocalisations are more expressive and structured than previously believed and are built from a repertoire comprising nearly an order of magnitude more than we ever knew."

X.9. WHAT IS REALITY?

Defining reality is challenging because it can be objective, subjective, inter-subjective, or even simulated. Our brains construct our perception of reality. The type of reality we usually refer to is objective reality or actuality, where things exist outside us and are not imagined or fantasised. Objective reality represents universal truths and applies to everything. For something to be considered real, it should be measurable, observable, and shareable with others. We should all be able to physically experience its existence through touch, sight, hearing, smell, or taste. Examples of objective reality include undeniable facts like the Earth orbiting the Sun, and the Sun rising and setting each day.

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[849] Evan Bush April 20, 2024. Scientists push a new paradigm of animal consciousness, saying even insects may be sentient. https://www.nbcnews.com/science/science-news/animal-consciousness-scientists-push-new-paradigm-rcna148213

[850] Sharma, P., Gero, S., Payne, R. et al. Contextual and combinatorial structure in sperm whale vocalisations. Nat Commun 15, 3617 (2024). https://doi.org/10.1038/s41467-024-47221-8. https://www.nature.com/articles/s41467-024-47221-8volumedetails

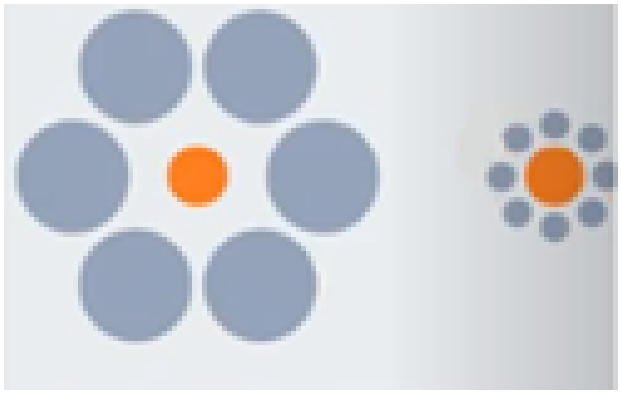
Subjective reality means something is real because you believe it is real, even if it may not be for everyone else. This is the world of emotions and feelings. For example, political and religious beliefs are personal realities created by our minds based on our beliefs.

Inter-subjective reality is constructed by human imagination and is the shared belief of groups of people. These beliefs can be so strong that they are almost considered objective reality. Some examples include money, gods, prophets, laws, and fame. Another example is COVID-19 deniers, who may believe so strongly in their perspective that even if they catch COVID-19, they argue it is something else.

Even objective reality can be distorted temporarily or permanently, depending on the brain's functioning. What one person perceives as real may not be perceived as real by another. This can be seen in the behaviour of individuals with mental health conditions or those under the influence of alcohol or drugs, which can influence their perception of reality. Various other factors can also affect how reality is perceived.

Optical illusions are excellent examples of false perceptions of reality. What appears to be true at first glance may actually be false. For instance, in figure below (Left), the central dot surrounded by smaller grey dots seems larger than the one surrounded by larger grey dots, even though the centre dots are the same size. Similarly, in figure below (Right), the rows appear to be tilted, but they are actually perfectly parallel.

Our reality is shaped by our subconscious, which is influenced by our life experiences. When faced with ambiguity, our brains fill in the gaps based on what we are most familiar with. This could stem from prior experiences or various aspects of our personality, as we all grow up in different circumstances. Unconsciously, our brains make inferences to resolve ambiguity based on these life experiences.



Two optical illusion examples.

When the information we receive is unclear, we tend to interpret it in ways that align with our desires and prior experiences. Our brains work hard to shape reality according to our emotions and discomfort with uncertainty. As said by Douglas Adams[851]: *"Everything you see or hear or experience in any way at all is specific to you. You create a universe by perceiving it, so everything in the universe you perceive is specific to you."* Our perception of reality is an output of the data collected by our sensory organs and the brain's processing of that data. In a world with literally infinite data, it is impossible that two people would be exposed to the exact same set of data. So, wherever you are, there is an infinite amount of data around you, and different people process the data they are exposed to differently. The pattern everyone makes out of data becomes their reality; their beliefs define their behaviour, and their convictions. This is why there's so much diversity in the thinking and behavioural humans.

For me, something is real if others perceive it the same way I do. This brown desk is real because we can all touch and see it is a big, brown, wooden table with four legs, stationary under my computer. My wife, children, and colleagues at work would agree on its appearance and feel. For an object to be considered real, it must be consistently perceived by everyone, unless the observer is under the influence of a mind-altering drug. In such a case, that person might see the table and the computer as something entirely different, depending on their altered state of mind. If they see the computer as "a belly dancer dancing on the brown wooden table," that perception is not reality but a product of the drug-induced state.

The human brain filters data it collects through an auto-selection mechanism, essentially making choices based on the information gathered by our senses. This process also involves drawing from long- and short-term memories. Our diverse life experiences shape our convictions, choices, and personalities, which in turn influence our perception of reality. Ultimately, how you perceive the world around you becomes your reality, shaped by your unique experiences and memories.

Tony D. Clark[852] cautions: "*Everything begins with a decision – decide now to be in charge of your own perception of reality. Because if you don't, there are plenty of folks whose sole purpose in life is to craft that perception for you*." For instance, in old movies, you will often see attractive men and women smoking cigarettes with charm and attitude, which helps explain why smoking became so

[851] https://www.lifehack.org/articles/lifehack/your-perception-is-your-reality.html

[852] Tony D. Clark, Why Your Perception Is Your Reality. https://www.lifehack.org/articles/lifehack/your-perception-is-your-reality.html

widespread[853]. The Italian TV series "L'Ora" demonstrates how far filmmakers can go to portray cigarette smoking as a normal part of life.

Beware of scammers, marketers, magicians, artists, advertisements, movies, politicians, and even those close to you like parents, friends and religious leaders. They often try to shape your perception to align with their own, using a range of tactics from simple persuasion to outright deception. Their goal is to make their perception your reality, regardless of its actual truth.

Another intriguing concept is simulated reality,[854,855] which suggests that reality could be simulated to an extent indistinguishable from actual existence. In such a scenario, simulated reality could contain conscious minds that may or may not be aware they are living in a simulation, similar to the premise of *The Matrix* movie, making it difficult or impossible to distinguish from true reality. This idea showcases the boundless nature of human imagination and how our perception of reality is a creation of the mind.

Philosopher Nick Bostrom[856] explored the likelihood of our reality being a simulation comparable to naturally occurring human consciousness. However, this proposition is disputed. Many argue that consciousness as we understand it, cannot be simulated.

Some have suggested that dreaming could be an example of simulated reality. In recent dream research[857], the notion of characterising dreaming as a form of simulation has gained traction, with various theories emerging about the purpose and functions of dreams. Both the dream argument and the simulation hypothesis are generally regarded as speculative. As René Descartes famously concluded, *"I think therefore I am,"* indicating that the existence of the argument itself is a testament to the possibility of its own truth. (op. cit.)

Some have taken this idea even further, claiming:[858] "*if we did not exist, the universe would vanish in a puff of smoke leaving nothing behind,* and even worse, *the universe is the creation of our minds*".

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853 It is sad to see even today in movie pictures the car driver turns his head to the passenger in the front seat and talks for ages while he drives. Everybody knows that if you do that in real life you will kill yourself and others in no time.

854 Not to be confused with Virtual Reality

855 https://en.wikipedia.org/wiki/Simulated_reality

856 Bostrom, Nick (2003). "Are You Living in a Computer Simulation?". *Philosophical Quarterly*. 53 (211): 243–255. doi:10.1111/1467-9213.00309

857 https://en.wikipedia.org/wiki/Simulated_reality

858 The Ultimate Mystery? –"Consciousness May Exist in the Absence of Matter" (Weekend Feature); Dailygalaxy.com; Posted on Sep 15, 2019 https://dailygalaxy.com/2019/09/the-ultimate-mystery-consciousness-may-exist-in-the-absence-of-matter-weekend-feature

John A. Wheeler's *Participatory Universe* or *Proto-Consciousness Field theory*[859] claims that *"consciousness is the life-force of the universe. Without it, the universe does not exist at all."*

Some even propose that this consciousness is emitted from a source somewhere in the universe, much like the Sun radiates light and heat[860]. According to the book *Anthropic Cosmological Principle*[861], the universe itself comes into being only if someone is there to observe it - the universe requires some form of life to be present, meaning that the universe could not exist without life within it. In this view, nothing exists unless there is consciousness to perceive it.

A claim that nothing exists unless there is a consciousness to apprehend it is a misconception. The stars, galaxies and the entire universe existed long before we were born and will continue to exist whether our conscious minds are present or not. Regardless of our existence, stars will keep shining, galaxies will keep rotating, and comets will continue their paths long after we are gone. A kitten would still play with grandma's knitting yarn even if we all suddenly disappeared from the face of the Earth. Birds would still migrate to places where their food is plenty, and salmon would continue their journey through Alaskan rivers to their birthplace. The rocks in the mountains and the sands in the deserts would remain, even if all living beings on Earth suddenly went extinct.

The universe will not disappear if humans or other conscious beings go extinct. The universe did not disappear when previous generations died. We are giving ourselves too much importance. Our minds may help the universe be aware of itself, but that is all. We are not the centre of the universe and should not exaggerate our importance. The moon was not created by Galileo merely observing it - it has been there well before us, orbiting the Earth. The fact is that before living beings even existed, the universe was already present. We come from the universe, but every living being is relatively recent.

We are simply another species in the animal kingdom, intellectually more advanced creatures than others due to our evolved brains. Consciousness is not unique to humans. Many animals show comprehension, self-recognition, and self-sacrifice. They socialise, communicate, cooperate, solve problems, and even display some mathematical skills[862]. These abilities might match those of a five-

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[859] Philip Perry, 25 June, 2017. https://bigthink.com/philip-perry/the-universe-may-be-conscious-prominent-scientists-state; https://futurism.com/john-wheelers-participatory-universe

[860] Philip Perry, The universe may be conscious, say prominent scientists. Mind & Brain newsletter 25 June, 2017

[861] John Barrow and Frank Tipler. The Anthropic Cosmological Principle. Oxford Paperbacks, Published: 7th April 1997, ISBN: 9780192821478, Number of Pages: 738

[862] https://www.thoughtco.com/most-intelligent-animals-4157712?utm_campaign=wilat&utm_medium=email&utm_source=cn_nl&utm_content=18171391&utm_term=list_gl_ot_thco-default CONSCIOUSNESS: HOW THE BRAIN CHEMICAL 'DOPAMINE' PLAYS A KEY ROLE – NEW RESEARCH PUBLISHED: AUGUST 4, 2021.

year-old human child, but so what? There will always be a creature more skilled than others to sit atop the pecking order, and on Earth, that creature happens to be a human being.

Let us remind ourselves that we are just one of those clusters of entangled vibrating atoms of the universe, but who can think about the fact that we are made of atoms. We just happen to have receptors to sense and interpret the vibrations of other objects, converting them into shapes, dimensions, and giving them names - something like a radio, a cell phone, or a TV set.

In summary, the short answer to the question of "*who are we?*" is that we are far more complex biological machines than any of the most impressive man-made creations. While achievements like building sophisticated supercomputers and landing rovers on the moon and Mars are remarkable, they pale in comparison to the intricate functioning of a single cell in our bodies.

A single cell can be likened to a large industrial park, where many factories produce and supply goods for each other. Cells have evolved sophisticated systems for energy production, feedstock supply, delivery systems to sustain their operation, waste disposal, and continuous self-renewal through reproduction. Most remarkably, these tiny cells organise themselves into functioning organs like beating hearts, breathing lungs, and limbs, all overseen by a commander in chief equipped with consciousness and a mind. While we can create walking and talking robots, we have yet to successfully create a tiny living cell.

In Anil Seth's words, we are *"biological, flesh-and-blood animals whose conscious experiences are shaped at all levels by the biological mechanisms that keep us alive".* This machinery did not come about overnight, but took millions of years to arrive at its present level of sophistication. We are an advanced product of a biological inheritance system which is driven by the survival instinct of selfish genes.

Without consciousness, time and matter are imperceptible. Consciousness provides a reference point, making time a measurable parameter alongside the three dimensions of length, width, and height. Inanimate matter lacks consciousness to perceive these aspects, it exists only as clusters of vibrating atoms without inherent awareness or purpose. Nevertheless, these bundles of vibrating energy exist regardless of the presence of consciousness. A thorough review of the topic can be found in an ArXiv paper "Consciousness as a State of Matter" written by Max Tegmark[863].

[863] Consciousness and Physics 1401.1219.pdf arXiv:1401.1219v3 [quant-ph] 18 Mar 2015

CHAPTER XI: THERE IS MORE TO THIS THAN MEETS THE EYE

"... One of the most difficult steps for any theoretical physicist: to determine the imprint of a new idea on our observable Universe, distinguishing that new idea from our old, prevailing ones. Until we successfully take that step, work will likely continue on these ideas, but they will only remain speculative hypotheses. We don't know whether our Universe was birthed by the creation of a black hole, but at this point, it's a tantalising possibility that we would be foolish to rule out." Dr Ethan Siegel - January 27, 2022, Hard Science.

XI.1. INTRODUCTION

What was before the Big Bang? How can a new universe emerge from nothing? These are lingering questions for which we lack definitive answers. Nevertheless, scientists have various ideas and hypotheses attempting to address these questions. The reality is that events preceding the Big Bang are beyond observation and measurement, thus remaining undefined. An honest response to the question "*What was before the Big Bang*" is simply "*we do not know*". As mentioned in Chapter VI.7, any attempt to answer is inevitably speculative; some speculations may be semi-scientific adorned with mathematics and equations, while others might be speculative and even resemble scenarios from Star Trek movies, although there are some that could be pioneering and in time convertible to hypothesis and even theories.

The answer to the question of "*what was before the Big Bang?*" is especially difficult, because any attempt at explanation inevitably leads to the question of what came before it. This dilemma is reminiscent of the old tale of the tortoise carrying the Earth on its back; as the story goes, the tortoise is carrying another tortoise, and so on. To avoid this infinite regression trap, scientists devised a clever idea: proposing that the Big Bang emerged from nothingness. This concept gained widespread acceptance because if the universe originated from nothing (a singularity), it does not require expansion into another space since there would be no external space beyond the universe. This point of view is explained in detail in Lawrence M. Krauss's book[864] *A Universe from Nothing.* In essence, the concept of the universe emerging from nothing is not far different from the theistic doctrine of '*Creatio ex nihilo*,' which claims that everything was created out of nothing by some divine creative act.

[864] Lawrence Krauss, 2012. A Universe from Nothing – Why There is Something Rather Than Nothing. Free Press eBook and Simon & Schuster, Inc. ISBN 978-1-4516-2445-8; ISBN 978- 1-4516-2447-2 (ebook)

One among the attractive ideas is the one claims that our universe exists within another structure, like a black hole, an idea that is scientifically known as the Baby Universe[865] and Black Hole Cosmological Model. For example, according to Nikodem Poplawski[866], the observable universe is in the interior of a black hole and it could be one of possibly many. Joel Smoller and Blake Temple (2003)[867] suggested that the "big bang" was an explosion inside a black hole, producing the expanding volume of space and matter that includes the observable universe. Ethan Siegel pointed out[868] the possibility that we could be living in a baby universe that looks like a black hole to outsiders. In his essay, Dr. Siegel was drawing our attention to the possibility that there could be an energy field inherent to space itself, causing the universe to inflate before and after the Big Bang.

String theory suggests that the Big Bang was not the beginning of the universe, but rather a result of a brane-antibrane inflation mechanism, which explains the exponential expansion of space in the early universe. This theory claims that the Big Bang could be triggered by the collision of two three-dimensional membranes, called 3-branes, which are attracted to each other by their opposite gravitational properties. The topic is extremely complex and beyond the grasp of individuals who do not hold a degree in theoretical physics or possess the extraordinary intellect of Sheldon, a character from the popular sitcom "The Big Bang Theory". If you are seriously interested in knowing more about the topic, please refer to the footnote[869]. To be honest, there is no satisfactory answer to the question of what happened before the Big Bang. Most scientists avoid this question because it seems it involves too many unknowns, as explained above.

In this chapter, we propose that an energy field exists before cosmic inflation and the Big Bang. We call this energy field the Substrate from which our universe originated. Under this concept, we assume that our universe, possibly along with others, grew within the Substrate that existed well before the Big Bang. Importantly, although this realm had some similarities, it was not a black hole. We acknowledge that what we propose here is also speculative. However, it is logically sound and philosophically more appealing than the claims that every black hole may give rise to many baby universes or the claim that "*the universe was created out of nothing*".

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[865] https://en.m.wikipedia.org/wili/black-hole-information-paradox

[866] Popławski, N. J. (2010). "Radial motion into an Einstein-Rosen bridge". *Physics Letters B*. 687 (2–3): 110–113. arXiv:0902.1994. Bibcode:2010PhLB..687..110P. doi:10.1016/j.physletb.2010.03.029. S2CID 5947253

[867] https://en.wikipedia.org/wiki/Black_hole_cosmology.

[868] Hard Science under the heading "Are we living in a baby universe that looks like a black hole to outsiders? on January 27, 2022. https://bigthink.com/hard-science/baby-universes-black-holes-dark-matter

[869] https://en.wikipedia.org/wiki/Cosmic_string or M. Gasperini and G. Veneziano. String theory and pre-big bang cosmology. IL NUOVO CIMENTO 38 C (2015) 160. Colloquia: VILASIFEST. DOI 10.1393/ncc/i2015-15160-8.

The speculative Substrate idea is largely based on the assumption that the virtual antigravitating negative quanta (negative mass and negative energy) exist, although their discovery is still pending.

Negative quanta repel each other and, in this respect, behave in an opposite manner to that of positive mass. The Substrate idea proposed here could become a credible theory only if one day the existence of quanta with repelling mass - often referred to as negative mass and negative energy, or dark energy - is demonstrated both theoretically and physically. Until then, it will remain one of many speculative ideas in physics.

In this and the next two chapters, we propose some new ideas based on the acceptance of repelling quanta as a reality. These repelling quanta can explain many unknowns and mysteries of the universe; they just need to be proven.

XI.2. WHAT IS SUBSTRATE? - THE SUBSTRATE IDEA

Substrate is the *Mother* of our universe - the place where our universe originated. It is the absolute ground state of our universe. It is like the Baby Universe in a black hole, but the Substrate is not a black hole. Yet, we see some similarities between the characteristics of the Substrate and the black holes: both are, assumedly, densely packed structures. Predictably, time stops in both. Both absorb light but neither of them emit light probably because they have an increased density. However, the Substrate is a space that existed before Cosmic Inflation and the Big Bang, and it does not contain a singularity point. Black holes, as far as we know at this point of time, are confined only to our universe (see Chapter VI. 10). The Substrate, as we propose it, is a stable Pre-Big Bang gravitational energy field that gives *birth* not only to our universe but possibly to other universes.

We introduced the Substrate idea under the notion that if 'nothing' is indeed 'something,' then we must consider alternative realms, as string theorists do. According to string theory, the universe exists in a higher-dimensional space, and a new universe could form when branes collide. This explanation provides the much-needed immense heat, akin to the Big Bang. Instead, we introduced a simpler idea, following Occam's razor, proposing that it would be easier to assume the existence of a Substrate rather than mathematically generated branes and multiple dimensions.

We realize that proposing the existence of something before the Big Bang inevitably raises questions about where, how, why, when, and what. Our response is that such questions are hard to answer because Substrate represents a different realm with potentially different laws of physics. The Substrate existed before our quantum space and the Big Bang, so the laws governing its physics likely differ greatly from our Quantum and Newtonian laws. This is understandable because we

know that the quantum world has laws distinct from those in the macroscopic world we live in. Our quantum mechanics is filled with phenomena which baffle us. In quantum mechanics, even the smallest probability of an event means it will happen if you wait long enough. We face many known unknowns, such as the physics of the black holes, Schrödinger's cat, quantum entanglement, and virtual particles appearing from vacuum. The physics of the Substrate must be governed by laws, the laws of the pre-quantum world, which deals with higher energy levels and roughly the Planck-size quanta in a predictably cold space. The laws of pre-quantum physics are dominated by temperatures extremely close to absolute zero Kelvin, or even negative Kelvin degrees (see further down in this chapter) in Kelvin scale. We will discuss the meaning of the negative temperature further down.

Some may dismiss the Substrate idea as another "cosmic tortoise"[870] exercise, but we categorically reject this notion. We emphasise that cause-effect questioning does not apply to this space, because the Substrate is a cold, tranquil, almost vibrationless and motionless place that has existed well before our universe. The question of "*what was before?*" is irrelevant here because, in this realm, there is no passing of time – no before, no after exists here. In our universe, time begins with the Big Bang and requires intelligent beings to perceive its passage and understand motion. As Stephen Hawking remarked[871], *"the Big Bang was the beginning of time and any event happening before the beginning of time can never be known as all the information prior to it is irreparably lost".*

The quanta that make up the Substrate are not matter and antimatter particles recycled from a pre-existing universe, nor are they quarks, leptons, or any form of antimatter. Matter like that would immediately annihilate, leaving no substrate. They are not detectable with our present instruments because they are orders of magnitude smaller, possibly in the vicinity of Planck size.

An imaginary depiction of four extremely exaggerated-size quantum dots. An infinite number of these dots makes up the Substrate. The coupled quanta is a densely packed, discrete entity that fills the entirety of the Substrate. In this figure, we arbitrarily assume that one half (say black for example) illustrates the attracting component, while the other half (white) illustrates the repelling component.

[870] This tortoise, the World Turtle or the Cosmic Turtle or the so-called World-Bearing Turtle, is a myth of a giant turtle (or tortoise) supporting or containing the world. It occurs in Hindu mythology, Chinese mythology, and the mythologies of the indigenous peoples of the Americas – see https://en.wikipedia.org/wiki/World_Turtle .

[871] Stephen Hawking (2011). A Brief History of Time – From the Big Bang to Black Holes. Bantam Press, ISBN 9780857501004.

We propose that the substrate is composed of two coupled quanta; we call it 'quantum dot.' One is a tiny attractive (so-called real or positive) quantum, and the other is a repelling (virtual or negative) quantum, which are fused together.

Our view is that our universe was nucleated within the Substrate, like a small cyst or a tumour in a lung, and has been expanding like a balloon since then. However, within the vastness of the Substrate, this expanding balloon is still insignificant in size and importance, much like Earth when compared to the entire Substrate.

We speculated that the Substrate space is filled with those coupled quantum dots, the smallest possible units of energy (or mass). In this respect, they are conceptually similar to the one-dimensional strings of the String Theory, but are one-dimensional dots.

We suggested each discrete quanta had two components coupled with each other as shown in the conceptual figure above: one gravitating (attracting) and the other anti-gravitating (repelling). These two opposite entities were coupled (or fused) together to form a quantum of unknown size, although we assumed it to be so small that it cannot be detectable with our best microscopes, and its energy is beyond the capabilities of particle colliders to accurately measure.

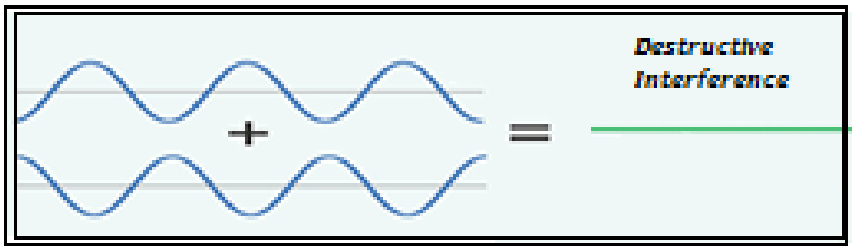
In the absence of any light, motion, electromagnetic or nuclear forces and spins in the Substrate, we reckon gravity to be the only reigning force in the pre-quantum space. Although the quantum dots and the substrate are motionless, each quantum has its own unique vibration pattern. The vibration pattern of the pulling quanta is opposite to that of the pushing quanta; so that these two opposing entities cancel each other's pull and push, resulting in a completely stable and create a motionless space.

The repelling and attracting quanta are made up of tiny quantum dots that contain some energy, possibly several orders of magnitude higher than the energies of electrons and protons. We avoided referring to the quantum dots as Planck particles because Planck's laws do not apply to the substrate. Planck's quanta belong to a metastable space (our universe) where light, heat, radiation, and matter reign, whereas the substrate represents a dark, cold, motionless universal true vacuum space.

For any attracting (real) mass to be part of the Substrate, it must be coupled with a repelling mass to maintain an equilibrium state. Under these conditions, the coupled quanta do not violate any conservation laws. We know as a fact that anything with positive mass attracts each other; therefore, although not discovered, the quanta with negative mass will do the opposite, namely push each other.

As we mentioned before, the Substrate is a space where there is almost no vibration or motion, which makes it an utmost stable universal ground state. However, such a claim raises an important question: How can systems be stable at universal ground state and simultaneously contain a large amount of energy? This paradox is addressed later in this chapter but here is a spoiler; An energy-rich system can remain stable if it is at a negative Kelvin temperature, where any added energy reduces the entropy instead of increasing it.

If you oscillate an electron back and forth, it will produce electromagnetic waves (photons) at the frequency of the oscillation. Likewise, if you oscillate (vibrate) a quantum particle (mass), it will produce gravitational waves (attracting or repelling quanta) at the frequency of the oscillation, possibly at a very long wavelength or at a unnoticeably slow rate. The manner in which a quantum vibrates (oscillates) determines whether it will be attractive or repulsive. If an attracting mass is coupled with a repelling mass - as in the case of the Substrate - they will appear to be vibrationless, because they will be in destructive interference mode, so that they completely cancel each other out. The destructive interference can result from the overlap of two waves, where the crests of one wave align with the troughs of the other wave, or when two identical waves are 180 degrees out of phase. If these two waves, with the same amplitude, are shifted by exactly half a wavelength, they will also cancel each other out.



The vibrations of attracting and repelling quanta cancel each other to give a vibrationless quantum dot.

The Substrate gives rise to the Big Bang following a brief inflation stage. Inflation (or cosmic inflation) is a local event during which the constituents of the substrate become decoupled and separated from one another. This occurs as a result of an event where their crests and the troughs are no longer aligned. Consequently, two separate quanta vibrating in opposition to each other are generated. This local disruption in destructive interference is assumed to be due to a local heat or energy surge.

The gravitational field around a positive mass is directed towards it so that they pull each other. Two negative masses repel each other because of Newton's law of gravitation, which states that the gravitational field around a negative mass is directed away from it.

The quanta, once decoupled, cannot couple again because the Big Bang temperatures are not conducive (high) for them to join, since re-coupling needs temperatures very close to absolute zero or probably even negative Kelvin degrees.

The Substrate idea suggests that a local nucleation of a tiny bubble would create an expanding bubble within the Substrate, which would grow to be our universe. In statistical terms (or logically), bubble creation from such a vast Substrate should be possible, even if the Substrate is a different realm, ruled by different laws. Anything not forbidden by conservation laws has a non-zero probability of occurring, even if small. We expected that such spontaneous splitting of the Substrate energy into an equal amount of positive energy and negative energy would not violate any conservation laws because no new energy would be created.

The Substrate scenario requires a trigger to nucleate an unstable spot - *the tumour or cyst* - to become an expanding bubble. We do not know exactly how this can happen, but we tend to think that a local change - a small variation in temperature or a decrease or an increase in the energy saturation level somewhere within the Substrate - could be responsible. We expect that once an unstable *sore-spot* is formed, the coupled quanta break up, separating the attracting quanta from repelling quanta. As the result of the decoupling, the force holding the two components is broken, and two separate entities form: one, discernible “positive” mass (real, gravitating) particles attracting each other, and two, antigravitating mass repelling each other, similar to dark energy.

We do not know if inflation was a violent event, but it is likely to be a non-thermal event, as it did not produce any of the known subatomic particles.

Once the attracting and repelling quanta were separated, the attracting quanta would start pulling towards each other, allowing them to cluster and aggregate, and then collapse to a point known as the singularity. The Big Bang is the result of a hot explosion of such a newly formed singularity. In contrast, once separated, the repelling mass exerts a repulsive effect on each other, which prevents them clustering and making their own atomic particles, as well as their celestial structures like stars or galaxies. They remain as tiny discrete particles. However, the repelling quanta fill the entirety of the newly forming universe; some occupy the interiors of galaxies, while others concentrate at the boundaries of each galaxy, and still others fill the void beyond the galaxies. We envision repelling quanta as a sort of superfluid that pervades all of the newly created expanding

space. When the gravitational forces of the attracting particles act upon them, they generate negative pressure.

In the empty, dark void between the galaxies, there will be only the repelling quanta (dark energy or negative mass), however, in the absence of a force applied on repelling quanta they will remain stable so that energy (repelling quanta) is not the main force causing the universe to expand. The expansion of the universe - as we will explain later - is the result of a runaway event: spontaneous conversion of potential energy to kinetic energy, created by the Big Bang.

Inside galaxies, matter dominates completely, and matter has mass. Gravity acting on mass generates positive pressure; therefore, we don't detect any effects of repelling quanta on Earth and within galaxies. In fact, repelling quanta are everywhere, filling what is believed to be empty space, including the interiors of atoms. For that reason we suggest that every real mass in our universe, from small to large, is immersed in a "*sea*" of antigravitating (repelling) quanta - or a negative-energy gravitational field - which is equivalent to the fabric of the universe: the spacetime continuum. In other words, the sea of the gravitational energy field generated by the negative quanta forms the fabric of the universe: the spacetime continuum.

Within galaxies, the stronger attractive force of matter with real (positive) mass is largely neutralized (or minimized) by the repelling force of the antigravitating quanta. This interaction leads to a gravitational equilibrium between them, resulting in a total energy of the universe being zero.

When we say a hydrogen atom is about 99.9999999999996% empty[872], this so-called "*empty*" space is expectedly not empty but filled with repelling quanta. In fact, without the repelling quanta filling this "*empty*" space[873], there would be no vibrating protons, neutrons, or hydrogen atoms - any atom, for that matter. Yes, heat makes matter and its atoms vibrate faster and faster as the temperature increases, but we suspect the fundamental reason for atoms to vibrate, even at near absolute zero, is their interaction with the surrounding repelling quanta - the sub atomic scale pull and push between them would appear to us as vibrations.

I have always wondered why the speed of light in the vacuum of our universe is not 200,000 km/s, not 500,000 km/s, or infinity but exactly 299,792.458 km/s. After all, we know that the speed of light changes with the density and refractive index of materials. The greater the refractive index, the denser the material, and the slower light travels through it. While we know the speed of light

[872] https://education.jlab.org/qa/how-much-of-an-atom-is-empty-space.html

[873] It is also believed that the binding energy of the gluon-quark interaction and the kinetic energy of the quarks fill the empty space.

varies from medium to medium it travels through - for example, in water to 225,000 km/s - what makes the photons or light waves have a fixed speed in vacuum, always exactly at 299,792.458 km/s? We answer this question by suggesting that a negative gravitational sea is another medium, although invisible to our current technologies, which set the speed of light to this value. If this logical deduction can be proven experimentally or theoretically, we would then also prove the existence of a negative gravitational energy field, in addition to other evidence, such as the fact that separating two positive masses requires expending energy against the gravitational force that pulls them together. This implies that the gravitational field possesses negative energy[874].

Assume that these light bulbs represent an array of repelling quanta - a scalar field - that fills the entire universe and creates its own gravitational energy field, acting like a sort of superfluid. Any disturbance to this field is transmitted across it, similar to one of those LED scrolling text displays. If the disturbance is light, the photons (or waves) of light will be transmitted in this medium as a straight line and always at the speed of 299,792.458 km/s.

The properties we attributed to the repelling quanta - especially the assumption that matter is enveloped by this invisible substance that fills empty space also permeates the space inside the galaxies. Although the force of these repelling quanta is weak against gravitating matter, it is still strong enough to move the galaxies away from each other. However, the attractive force holding galaxies intact is more powerful than the repelling force, which prevents galaxies from expanding despite the strong gravitational pull between stars.

XI.3. Negative Mass: The Antigravitating Quanta

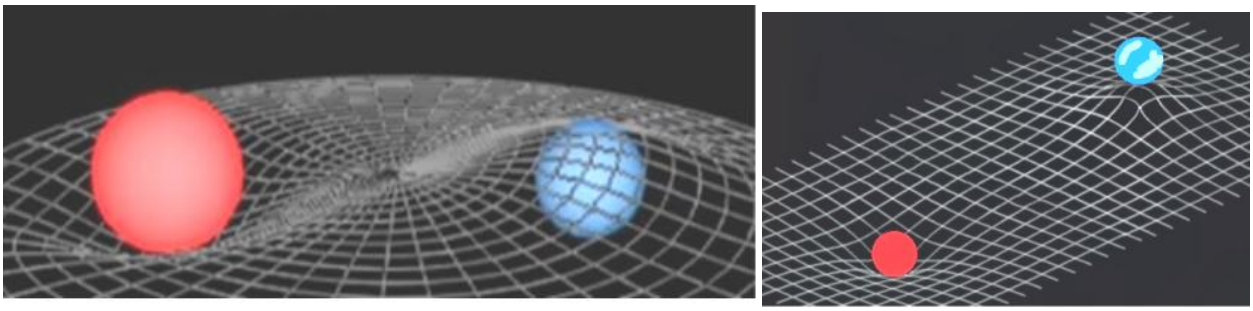
As far as we know, in our universe mass is always and everywhere positive, and there is no particle or object that can cause a weighing scale to move backward. Although negative mass is unintuitive and carries misleading connotations, there are many scientific articles speculating about the universe containing negative masses. The terms 'negative mass' and 'negative energy' are used extensively in scientific literature. For example, the term 'negative mass' is explained on

[874] Wikipedia: Gravitational_Potential

Wikipedia[875] as a hypothetical type of exotic matter whose mass is of the opposite sign to that of normal matter. We see the negative mass opposite of mass that attracts each other.

Physicist Professor Hermann Bondi (1957)[876] suggested in a paper published in *Reviews of Modern Physics* that mass might be negative as well as positive. He pointed out that this does not imply a logical contradiction, as long as all three forms of mass (inertial, active, and passive gravitational mass) are negative. The most thorough paper on negative mass is that of Bondi [(op.Cit)]. He points out that positive and negative masses can coexist in the universe. Hermann Bondi was the first to explore the gravitational interactions between masses with positive and negative signs, based on the Newtonian approximation of the Einstein field equations. As reported in Wikipedia[877], Bondi showed that an object with negative inertial mass would be expected to accelerate in the opposite direction to the applied force. He noted that a positive mass attracts both other positive masses and negative masses, due to the gravitational pull they exert on one another, causing an attraction; conversely, two negative masses would repel each other because of their negative inertial masses.

Different authors envision that negative and positive masses induce different gravitational potentials in spacetime, as shown in the figure above. Positive mass (shown in pink) induces a gravitational potential shaped like a *gravity well*, into which other masses fall. This is why matter is always gravitationally attractive. Classically, in general relativity, hypothetical 'exotic matter' made of negative mass (shown in blue) would conversely trigger an opposite gravitational potential in spacetime, shaped like a *gravity hill* or a *bulge)*. Such a negative gravitational potential would repel any other masses nearby, including other negative masses.



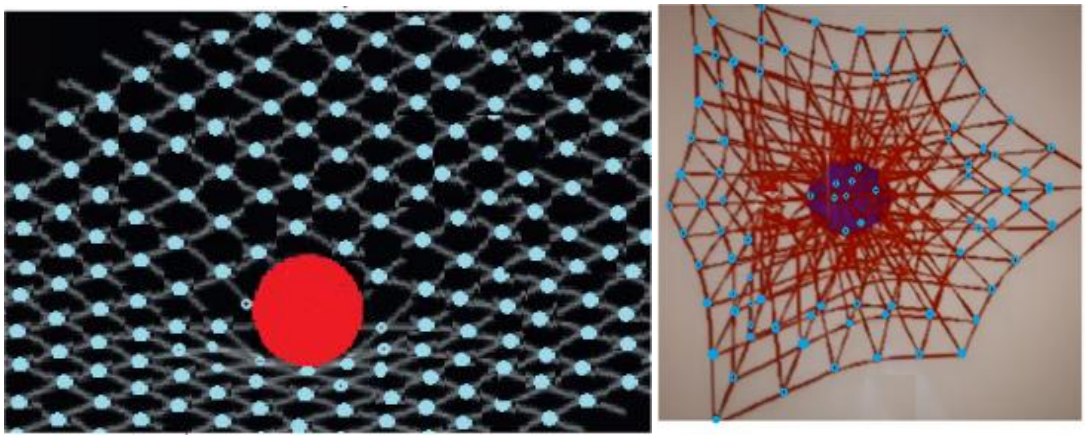
Some scientists depict the negative mass (blue, right ball) either residing below or above the fabric of spacetime, causing it to bulge. On the other hand, positive mass (pink, left ball) induces a sinking well of gravitational potential in spacetime.

875 https://en.wikipedia.org/wiki/Negative_mass

876 Negative Mass in General Relativity (1957). *Reviews of Modern Physics*, 29(3), 423–428. Bibcode:1957RvMP...29..423B. doi:10.1103/RevModPhys.29.423)

877 https://en.wikipedia.org/wiki/Negative_mass

The next two figures represent our view and show that the negative gravitational potential does not create a bulge - gravity hill. This is because repelling quanta, as described by Bondi, two negative masses would repel each other because of their negative inertial masses. This means that the repelling quanta cannot cluster to form larger particles. Rather, they form the fabric (spacetime) of the universe which is a network made by tiny repelling quanta. In other words, spacetime is a 3D network made from tiny, discrete repelling (negative) quanta. This explanation transforms spacetime from a mathematical model that describes the universe into the word 'fabric' as a conceptual analogy.



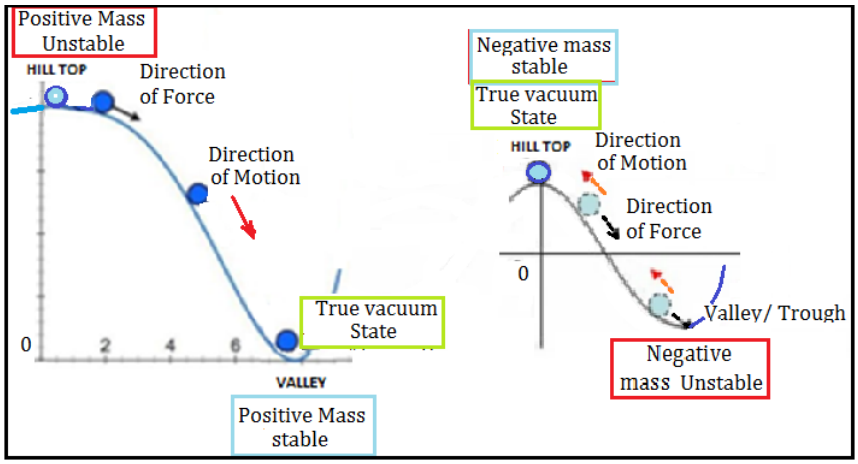
The above figures are a two- and three-dimensional representation of the fabric of the universe. These figures illustrate that the fabric (spacetime) of the universe is a scalar energy field - a network made from tiny, discrete, repelling quanta (small blue/green dots). In 2D, the positive mass, cannonball, would create a sinking well. In 3D, the cannonball would appear pulling the fabric from every direction.

We applied Prof. Bondi's teaching: "*An object with negative inertial mass would be expected to accelerate in the opposite direction to the applied force,*" to explain how dark matter forms a halo around galaxies. We assumed that dark matter, like dark energy, is the fabric of space, the space that is made up of repelling quanta as we talked about earlier. If this is the case, then negative mass, the repelling quanta, will accelerate toward the push of the centrifugal force created by the rotating galaxy until a state of equilibrium is reached and the outward force is neutralized. The push against the centrifugal force would squeeze the fabric of space and compress a thick layer of repelling quanta so that, to an observer, the compressed fabric of space will appear as a halo around the galaxy (see figure below).

This explanation not only clarifies why the stars at the outskirts of the galaxy do not fly away, but it also serves as proof for the existence of dark matter - upgrading its status from virtual or imaginary to real - not detectable with our most advanced instruments.

Our interpretation of dark matter - the halo - around the galaxies: The repelling quanta accelerate toward the push of the centrifugal force created by the rotating galaxy until a state of equilibrium is reached and the outward force is neutralized.

Choi and Rudra' paper[878] explains what happens if a cannonball with negative (repelling) mass is rolled from the top of a hill (*gravity hill*) to the valley (*gravity well*) at the bottom (see the RIGHT figure below). It appears that the maximum stability for negative mass coincides with the minimum stability of positive mass. The reason for this seems to be that the positive energy of the false vacuum is compensated by the negative energy of gravity; namely, when one increases, the other decreases.



Stability of a cannon ball made out of negative mass - assuming it exists - (Right) compared with positive mass (Left). The ball on the right has the highest stability at the top of the hill, where it possesses kinetic energy. In contrast, it is least stable at the bottom of the hill, where it is filled with potential energy. The ball on the left has the highest stability at the bottom of the hill, where it possesses kinetic energy. In contrast, it is least stable at the top of the hill, where it is filled with potential energy. The two figures show the potential and kinetic energies being in a constant state of equilibrium.

[878] Choi and Rudra. Pair Creation Model of The Universe From Positive and Negative Energy. https://vixra.org/pdf/1403.0180v1.pdf

When our universe reaches its universal ground state all its potential energy converts to kinetic energy. If this kinetic energy is channelled back to the Substrate, this would seem as if the Substrate is *feeding* on the energy of dying universes and answers the question: *where did the Substrate get its kinetic energy?* This feeding binge becomes an exclusive splurge if the Substrate repeatedly gives rise to multiverses, and *feeds* on their kinetic energy, probably for its own survival.

Once the universe was born, the rules of our physics - both quantum and Newtonian – come into action. The gravitating quanta with real mass gradually evolve into atoms, molecules, and eventually massive objects like stars and galaxies scattered throughout the spacetime of the Big Bang universe. Meanwhile, the anti-gravitating quanta[879] fill the newly created space and form the spacetime continuum. In the Substrate idea, the expanding bubble - the new universe - will eventually cease to exist. The sore spot will eventually diffuse back into the Substrate and the decoupled gravitating and repelling quanta will recouple, equilibrate and become part of the stable Substrate again. At the end, the bubble would disappear like a healing wound or cyst, leaving no trace; as it heals, other bubbles are likely to randomly appear and disappear in different sectors of the Substrate.

XI.4. The Paradox of Infinite Amount of Energy At Absolute Universal Ground State

We mentioned earlier that the Substrate is stable in its ground state while containing an infinite amount of potential energy. This contradicts the well-known fact that, in our world, at the true vacuum state, the potential energy of a system approaches zero in its ground state. In terms of thermodynamics, normally, as temperature increases, so does the randomness of the molecules, leading to an increase in the entropy of the system so the system becomes more unstable. However, in the case of the Substrate, the entropy (randomness) of a system decreases so that the system becomes more stable, as energy is added to it.

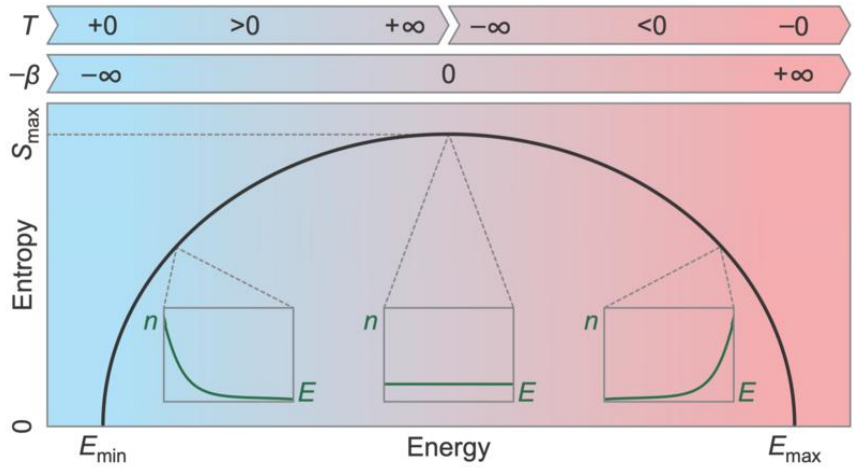
The claim that the Substrate contains an infinite amount of energy is not because of a single quantum, which might seem to have only a little vibrational energy, but rather because of its infinite number of quanta. Yet, the substrate is at its absolute ground state. This is contradictory and raises the question: How can the substrate be stable in its ground state while also containing an infinite amount of entropy (randomness) and potential energy?

[879] By pushing each other yet its existence remains to be proven.

We resolve this paradox by referring to the work of others, especially Braun et al. (2013)[880], who showed that an energy-loaded system can remain stable if it is at a negative Kelvin temperature. Their laboratory demonstrations show that a negative Kelvin temperature can be just as stable as a positive temperature.

Negative temperature is a known concept in thermodynamics, where a system's temperature can be negative if it is defined via entropy. In the conventional understanding, temperature cannot be less than absolute zero, the point at which all molecular motion ceases. Conventionally, entropy increases with increasing energy. However, in an entropy vs. energy distribution, the entropy of a system can decrease as energy is added, as shown in the figure below based on the equation $1/T = \partial S/\partial E$, where T is temperature in Kelvin (K), ∂S is entropy (randomness), and ∂E is energy.

Figure below, from Max Planck Institute of Quantum Optics in Garching, shows a typical entropy versus energy curve in a system that ranges from a minimum (E_{min}) to a maximum (E_{max}) energy. The slope of this curve indicates how entropy changes with energy ($\partial S/\partial E$) and therefore gives the inverse temperature (1/T) where accordingly the temperature scale changes from +0,..., to +∞ on the left (green/blue) side and ,-infinity,... at the centre, and -10,..., -0 -∞ on the right (Pink) side.



Entropy versus energy curve of a system ranging from a minimum (Emin) to maximum (Emax) energy[881]. This figure shows that A negative temperature occurs when adding energy to a system reduces entropy. This is in contrast to a positive temperature, where adding energy increases entropy. *Source:https://www.quantum-munich.de/119947/Negative-Absolute-Temperatures; Max Planck Institute of Quantum Optics in Garching; Negative Absolute Temperatures*

[880] S. Braun, J. P. Ronzheimer, M. Schreiber, S. S. Hodgman, T. Rom, I. Bloch, U. Schneider. Negative Absolute Temperature for Motional Degrees of Freedom. Science, 2013; 339 (6115): 52 DOI: 10.1126/science.122783; https://www.sciencedaily.com/releases/2013/01/130104143516.htm

[881] Max Planck Institute of Quantum Optics in Garching; Negative Absolute Temperatures https://www.quantum-munich.de/119947/Negative-Absolute-Temperatures

Let us note that: Entropy (S) and Energy (E). Entropy is a measure of the disorder or randomness in a system, while energy is a measure of the system's capacity to do work. The relationship between these two quantities is crucial in understanding thermodynamic processes. Slope of the Curve ($\partial S/\partial E$): The slope of the S vs. E curve represents how entropy changes with energy. Mathematically, this is expressed as ($\partial S/\partial E\}$). Inverse Temperature (1/T): In thermodynamics, the reciprocal of temperature (1/T) is proportional to the change in entropy with respect to energy. Thus, we can relate the slope of the curve to temperature through the formula: ($1/T = \partial S\backslash\partial E$). This means that when ($\partial S/\partial E$) is positive (as it typically is in the case of most systems), the temperature is also positive. The Temperature Scale described above suggests that as we move leftward on the graph from the minimum energy (E_{min}), the temperature increases positively from 0 to $+\infty$. Conversely, when moving towards maximum energy (E_{max}) and entering the central region or beyond, the values change to negative temperatures. Negative temperatures arise when a system has more high-energy states filled than low-energy states - a counterintuitive situation that can occur in certain physical systems like lasers or certain spin systems.

Let us also note that systems with negative temperatures are not colder than absolute zero; rather, they can be interpreted as having a higher form of disorder at certain energy levels, and they can exhibit unusual properties, such as being able to transfer energy to systems at positive temperatures.

The negative temperature is an old and known concept and referred to it by Purcell and Pound (1951)[882] from Harvard University. They were probably the first to carry out an experiment and publish a paper in a scientific journal on negative temperature. In their experiment they showed that a negative temperature occurs when adding energy to a system reduces entropy. This is in contrast to a positive temperature, where adding energy increases entropy.

Braun et al[883] showed that it is possible to create a system with a negative Kelvin value in a laboratory setting This is done by putting a gas of ^{39}K bosonic atoms into an abnormal state, where more atoms than normal are in a high energy state. When the atoms drop back into a lower energy state, they give off energy as a beam of laser light. This abnormal distribution of atoms can result in a negative number when solved for temperature.

[882] E. M. Purcell and R. V. Pound (1951). A Nuclear Spin System at Negative Temperature, Published in Phys. Rev. and is available at doi.org/10.1103/PhysRev.81.279.

[883] Max Planck Institute of Quantum Optics in Garching; Negative Absolute Temperatures https://www.quantum-munich.de/119947/Negative-Absolute-Temperatures;

Negative Kelvin temperatures have several unusual consequences, such as negative pressure in a gas without the gas collapsing. However, negative Kelvin temperatures are actually hotter than all positive temperatures, including infinite temperature. Heat always flows from hotter to colder systems, so heat will flow from negative temperature systems to positive temperature systems.

In this context, negative temperature occurs when a system has more energy in its high-energy states than in its low-energy states. This can happen in systems such as specific solids or gases, under particular conditions. At a negative temperature, the system has more energy than it would at any positive temperature. This means that it can transfer heat to a positive temperature system, contrary to everyday experience.

An example of a system which can exhibit negative temperature is a group of atoms trapped in a laser beam, as demonstrated by Braun et al. In this case, the laser beam pushes the atoms into a configuration where their high-energy states are more populated than their low-energy states, resulting in a negative temperature. Negative temperature has also been observed in certain magnetic systems and some types of ultra-cold atomic clouds.

A doctoral student, Simon Braun explains this paradox to the Science Daily[884] as follows: "*In our world, under ambient temperatures, if a ball (a* sphere) *lies in a valley* (like the Mariana Trench) *it will be at minimum potential energy, at a stable state. If this ball is located on top of a hill it would be unstable at its maximum potential energy, and will roll down thereby converting its potential energy into kinetic energy. However, the things will be different if the ball is at a negative temperature and consequently it stays there intact on top of the hill because its kinetic*[885] *energy will already be so large that it cannot increase further".*

Braun and his team in their article published in *Science* claim to have created the first negative absolute temperature state for moving particles. They describe how they created an atomic gas in the laboratory with negative Kelvin values. *Science Daily*[886] highlights *"these negative absolute temperatures have several apparently absurd consequences: although the atoms in the gas attract each other and give rise to a negative pressure, the gas does not collapse – a behaviour that is also postulated for dark energy in cosmology".*

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884 S. Braun, J. P. Ronzheimer, M. Schreiber, S. S. Hodgman, T. Rom, I. Bloch, U. Schneider. Negative Absolute Temperature for Motional Degrees of Freedom. Science, 2013; 339 (6115): 52 DOI: 10.1126/science.122783; https://www.sciencedaily.com/releases/2013/01/130104143516.htm

885 Temperature relates not only to kinetic energy, but to the total energy of the particles, which in this case includes potential energy.

886 https://www.sciencedaily.com/releases/2013/01/130104143516.htm

We are aware of the fact that Braun and his team's experiment is not proof of the existence of the Substrate; however, the concept of a negative temperature occurring when adding energy to a system, which reduces entropy, is applicable to solving the puzzle of what was before the Big Bang .

XI.5. Absolute True And False Vacuum (Or Ground) States

Let us remind ourselves that in quantum mechanics, the ground state, also known as the true vacuum state, represents the lowest internal energy state possible for a system or object[887] on Earth. To illustrate this concept, consider a cannonball rolling down Mt Everest towards Ganges River near Delhi. In this scenario, the Ganges becomes the first temporary ground state for the cannonball. If the ball continues rolling into the Indian Ocean, the Indian Ocean then becomes its second ground state. Dropping the ball into the Pacific Ocean south of the Island of Guam and allowing it to roll to the deepest point on Earth, the Challenger Deep of the Mariana trench (-10,994 metres), establishes the universal ground state or absolute true vacuum state for the cannonball on Earth.

In this state, atoms, molecules, or particles reach their stable ground state where the potential energy of the ball from the higher elevation (Mt. Everest) is completely converted into kinetic energy. You can test the validity of this statement if you try to roll the cannonball from the Mariana Trench back up to the summit of Mt Everest and quickly see that such an act would require a significant input of energy. You can test the validity of this statement by trying to roll the same cannonball from the Mariana Trench back up to the summit of Mt. Everest, quickly realising that such an act would require a significant amount of energy. When the ball reaches the summit the ball will gain back all its spent potential energy.

The electron shells of atoms - K, L, M, and so on – serve as other examples of ground states. Each electron shell represents the lowest energy state for the orbiting electrons[888] within the atom.

A false vacuum state is a hypothetical state where a field appears to be a vacuum but is unstable. It is a metastable state, in which the object is temporarily trapped. In the analogy of the cannonball rolling downhill, the ball reaches a metastable or false vacuum state as it rolls from a higher elevation to a lower elevation. A metastable state or a false vacuum, has potential energy greater than the ground state. It is like an anomalous peak along the path of the cannonball down the mountain, which is higher than the ground level but lower than the starting point. Every matter system has its own ground state, referred to as a degenerate ground state. In the cannonball

[887] https://en.wikipedia.org/wiki/Ground_state
[888] https://imagine.gsfc.NASA.gov/science/toolbox/atom.html

analogy, Ganges and the Indian Ocean represent degenerate ground states. The Mariana Trench serves as the true absolute ground (or vacuum) state on Earth, where the cannonball would come to its final rest.

The true absolute ground state of our universe, as we call it, is the Substrate, the realm that our universe arose. In the above analogy, our universe is rolling (or a better word, expanding) like a ball to the bottom of the Mariana Trench, but in this case, the universe is expanding into the Substrate. The absolute (universal) true vacuum of our universe is the Substrate; the universal lowest energy state achievable. This is the place where all systems and quantum fields have reached their minimal energy levels. To emphasize again, the substrate we refer to as the fundamental ground state of our universe is also where our universe originated.

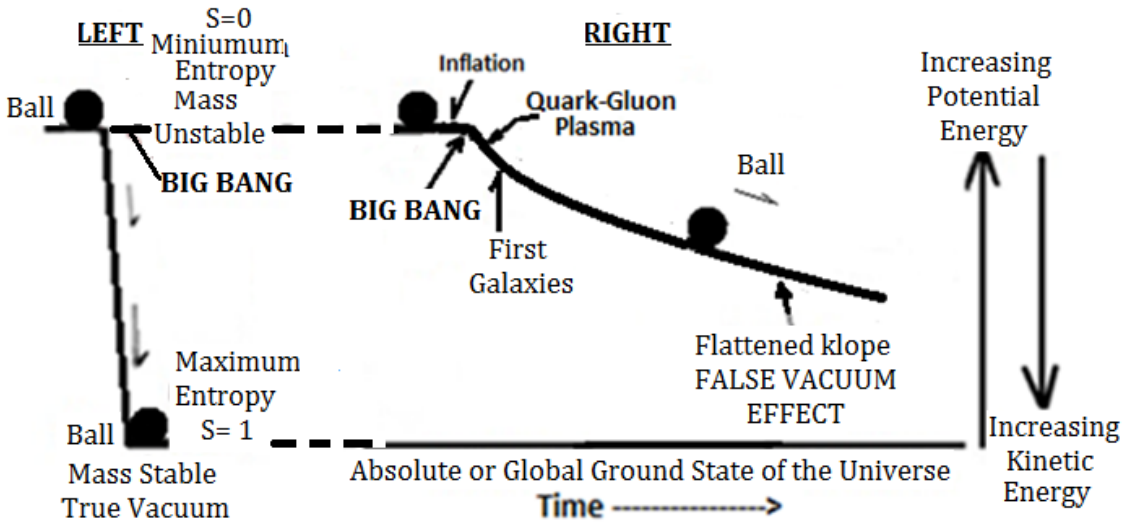
Our universe is at this point of time at a metastable, so-called false vacuum (or false ground) stage. According to the third law of thermodynamics, every system eventually reaches its ground state at absolute zero temperature. However, achieving absolute zero is theoretically impossible through standard thermodynamic processes on Earth, as the substance being cooled approaches the temperature asymptotically. Consequently, even at absolute zero, matter retains quantum mechanical zero-point energy, creating a false ground state. This phenomenon likely explains again on Earth why a vacuum is not entirely empty, exhibiting quantum fluctuations and the emergence of pairs of electrons and positrons which momentarily appear and annihilate each other, releasing energy back into the vacuum in the form of light or gamma rays.

XI.6. CONTAINING THE RUNAWAY ENERGY OF THE BIG BANG

We said the biggest threat to the existence of the universe is the runaway kinetic energy released by the explosive Big Bang. We believe that without intervention, the decay - the conversion of potential energy into kinetic energy, heat, and radiation - would be swift and would bring the newborn universe immediately back to its absolute ground state, merging into the Substrate (see the left figure below). This risk arose from the very first second of the Big Bang. If the immense heat and radiation - the kinetic energy released from the bang - had not been at least partially contained, the universe would have ended as soon as it began. The released kinetic energy would rapidly dissipate into the Substrate, and would quickly reach equilibrium. This scenario is depicted in the left figure below, akin to the cannonball once perched on top of a hill now resting motionless and vibrationless at the bottom of a valley – having settled into its ground state.

In this section, we will discuss what caused the decay to slow down and point out right away that we are still here; therefore, such a catastrophic scenario so far did not unfold. Somehow, this

instant death was prevented, or at least slowed down. In the right figure below, the flattening of the slope of the curve indicates the conversion of runaway kinetic energy from the Big Bang into



The sharp drop of the ball (Left) represents the runaway kinetic energy scenario, the instantaneous death of the expanding universe. In this scenario, the kinetic energy released from the Big Bang is not contained. The gently decreasing slope (Right) represents a partial aversion of the runaway threat. This aversion is due to the formation of billions of galaxies and their trillions of celestial objects like black holes, stars, planets, and all living organisms on Earth - all representing newly made potential energy silos.

potential energy: first as plasma at temperatures reaching trillions of Kelvin, then coalescing into subatomic particles like quarks and leptons. As the universe cooled further, nucleosynthesis reactions created the very early atoms, paving the way for the formation of increasingly heavier atoms, molecules, and massive objects like stars, galaxies, interstellar clouds, black holes, and eventually life on Earth. Each of these objects, from the smallest to the largest, represents distinct layers of degenerate ground states (false vacuums). These objects all possess positive mass and exert gravitational attraction. The larger their mass, the more effectively they remove runaway kinetic energy from the Big Bang. We refer to them as potential energy silos.

The relationship between kinetic and potential energy is inversely proportional. As one increases, the other decreases. This process adheres strictly to the law of conservation of energy - no energy is created or lost in this exchange. It is precisely this mechanism which the universe uses to delay its own inevitable end.

Every potential energy silo converts runaway kinetic energy into potential energy to store as long as possible. These objects with positive mass exert strong gravitational attraction, holding each other tightly, preventing the expanding universe from tearing them apart.

The early inflationary expansion (or decoupling) does not affect the slope of the right curve in the above figure as it was a non-thermal event. The steep descent of the slope represents the onset of the Big Bang. Over time, the curve *flattens* due to the formation of massive objects like galaxies, black holes, stars, and planets.

The potential energy of solid objects increases with the increase in their mass because a greater mass results in a stronger gravitational force. Larger objects therefore have more potential energy. Heavier atoms store more potential energy than lighter atoms. This is why galaxies contain significantly more potential energy compared to interstellar voids. The formation of orderly structures creates multiple layers of false vacuums, slowing the progression toward the universal ground state.

Consider the cannonball analogy in real life: as the ball rolls down a hill, its speed increases because its potential energy decreases, while its kinetic energy increases. Such a scenario may explain the accelerated expansion of our universe. When the ball reaches the bottom, all its potential energy is converted to kinetic energy, reaching its maximum kinetic energy at that point.

The universe today is much larger, cooler, and filled with stars and galaxies, compared to 400 million years after the Big Bang[889]. The increase in the number of stars and gravitational objects like galaxies and black holes keeps the universe away from reaching the absolute universal ground (true vacuum) state. Galaxies merge to form clusters, collide to create larger galaxies, and more stars. This continuous formation of celestial objects delays a quick end to the universe.

The present number of objects is insufficient to prevent the actual end to the universe, because known celestial objects account for only 4.5 - 5%[890,891] of the universe's mass. This represents only a fraction of the kinetic energy released by the Big Bang. To keep the universe's expansion in check, more mass and more massive objects are needed.

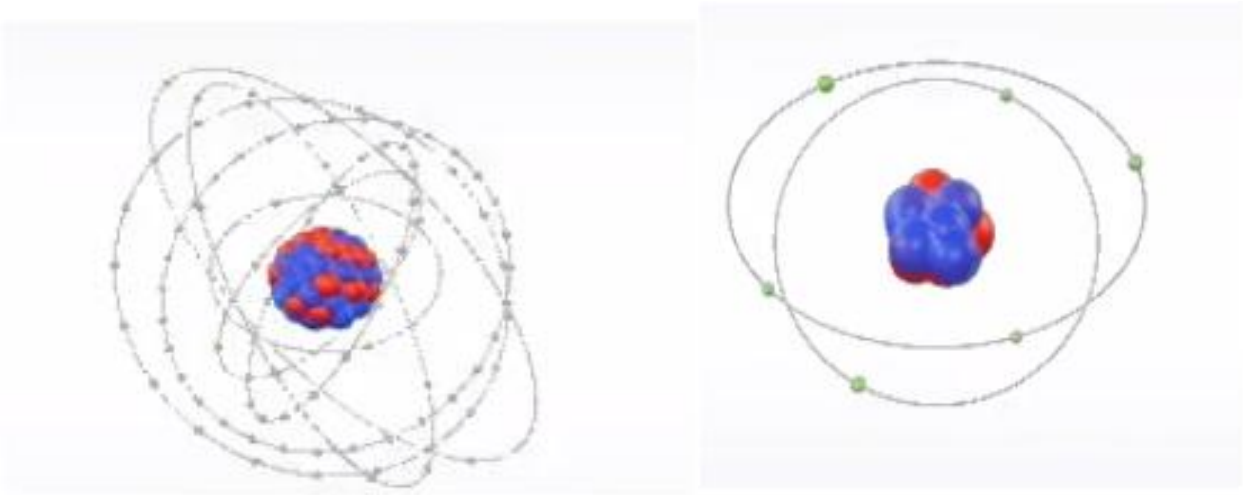
The universe addresses this by creating more energy storage silos. Firstly, by making increasingly heavier elements - heavier atoms have a higher energy storage capacity. For example, uranium, with an atomic number of 92 (92 protons or electrons), contains more potential energy than bituminous coal, made from carbon atomic number 6 (6 protons or electrons, as shown in figure

[889] https://en.wikipedia.org/wiki/Chronology_of_the_universe

[890] Richard Panek, 2021. The 4-Percent Universe: Dark Matter, Dark Energy, and the Race to Discover the Rest of Reality – Publisher Houghton Mifflin Harcourt

[891] Atul Kedia, a Follow of Quora, explained how the mass of the universe was calculated https://www.quora.com/How-do-we-calculate-the-mass-of-our-known-universe?

below). Burning one kilogram of coal produces 8 kW of power per hour, while one kilogram of natural uranium generates 45,000 kW of power per hour[892].



The more complex uranium atom, left, contains more energy than the simpler carbon atom, right. Both of them are made out of absorbed energy. We know this from the energy (heat and light) released when we burn coal and blast uranium, or smashing particles in the Large Hadron Collider.

Heavier atoms are formed during supernova explosions. When a massive star dies, it undergoes a supernova and its core collapses under its own gravity - becoming extremely hot. This intense heat allows atomic particles to go through another set of nucleosynthesis reactions, forming heavier elements on the Periodic Table.

Energy, heat, and radiation released from a supernova explosion do not change the net energy balance by adding new energy to the universe. This is because the supernovae themselves were initially formed from kinetic energy released by the Big Bang.

The energy released from exploding supernovae is mostly recaptured in the creation of new potential energy silos. These silos first take the form of gas, dust, planetesimals, and debris, which then coalesce into new stars, planets, and other celestial bodies. This recycling process allows old, dying stars to renew and recycle themselves so that they keep going.

Another example includes the formation of molecules, crystals, ores, minerals, rocks, oceans, and rain clouds - all of which store huge amounts of potential energy from the Big Bang. These minerals

[892] https://lowcarbonpower.org/type/nuclear

create coal, lignite, natural gas, and uranium ores, which serve as high-capacity energy silos cleverly tucked away underground on Earth.

In summary, if the universe had not begun creating these false vacuum traps - potential energy silos- and had not partially converted the runaway heat and radiation back into potential energy, the newly formed universe would have expanded at the speed of light and ended quickly. The creation of atoms, molecules, rocks, and minerals helps delay such a swift end.

These orderly structures help counteract the disorder introduced by the Big Bang like a tug of war. The runaway energy was, and still is, a threat to the universe's very existence and to all living beings. It appears as though the "*selfish gene*" of Richard Dawkins is aware of this runaway kinetic energy threat and also wants to survive and avoid a dreadful end.

Is Expansion a Friend or Foe?

The Substrate idea also proposes that the universe's expansion is not the main threat to its end, contrary to theories like the big rip, big freeze and big bounce. Instead, it is the runaway energy release created by the Big Bang which poses the most concern.

To put it into perspective, the universe's expansion has been crucial for its existence. Without expansion, the hot soup formed right after the Big Bang would never cool to create hydrogen, helium and a little bit of lithium. Without hydrogen and helium, there would be no other atoms to fuse together to make other atoms.

If the universe suddenly stopped expanding, all the galaxies would stop moving away from each other. Their immense gravity would cause them to attract and collide,[893] forming a giant supernovae. This supernova would eventually collapse and explode, creating huge gas clouds and fragments of new matter. Without expansion, there would be no cooling, and the universe would repeatedly collapse onto itself. No life could arise in such a hot, hostile environment. Therefore, expansion is our friend – without it, the evolving universe as we know it would not exist. The biggest enemy or threat to the existence of us and the entire universe is actually the runaway kinetic energy set upon us is the Big Bang. The biggest threat to our existence and that of the entire universe is the runaway kinetic energy unleashed by the Big Bang.

[893] Because, masses always attract each other.

XI.7. Living Beings Are Renewable Potential Energy Silos

The universe's most advanced method of combating the runaway kinetic energy appears to be the creation of "*self-duplicating*" living organisms – at least on Earth. Biological evolution has produced increasingly complex structures - plants, animals, bacteria, fungi – all endowed with the ability to replicate themselves. These self-replicating energy storage silos are the pinnacle of evolutionary achievement, ensuring the survival of the universe.

Living organisms consume energy to grow and sustain themselves, using it to build body parts, bones, muscles, support brain functions, and perform physical activities. Although they generate and expend energy, they also release sweat, urine, faeces, and carbon dioxide into the environment. What is released into the environment are usually other forms of potential energy. In this way, living beings continuously transform and store potential energy from one form to another.

Jaeger and Liu (2010)[894] explained, *"the energy that continually strikes the earth from the sun is the source of life on Earth. If solar energy were no longer supplied, many systems on Earth would revert to equilibrium"*. Without energy from the sun, life on Earth would cease to exist.

Water vapour in clouds gathers to form rain and snow, which as liquids and solids, are more orderly structures than the vapour (gas). Living organisms - orderly solid structures made from molecules, tissues, bones and muscles - consume air, water, and nutrients, such as by eating other organisms.

The Sun's energy, through photosynthesis, reduces disorder by constructing orderly structures like grass and trees. While these life forms generate heat and may appear to increase disorder,[895] they do not add any new energy to the balance of the universe. They merely convert energy from one form to another.

When a tree falls and decomposes, the energy initially acquired from the Sun is released (partially) back into nature. The decayed leaf becomes a nutrient for the soil, supporting the growth of other plants like trees, grass, or dandelions. This interconnected ecosystem ensures that all living beings work together (in harmony) to delay reaching the universal ground state.

The human body stores potential energy by forming bones, muscles, tissues, and blood, which requires consuming carbohydrates, fats, proteins, and water. Once digested, solid food breaks down

[894] Heinrich Jaeger, Andrea J. Liu, 24 Sep 2010. Far-From-Equilibrium Physics: An Overview. ArXiv:1009.4874

[895] We say "ideally" because humans add significantly to the entropy by consuming coal, gas and uranium and releasing high amounts of heat and greenhouse gases.

into water, carbon dioxide, and adenosine triphosphate (ATP). ATP molecules are used whenever energy is needed - for breathing, running, thinking, or playing sports.

Glucose is a vital energy source for cells. When not immediately needed, glucose is stored as glycogen in the liver and muscles. Glycogen and glucose molecules enter the cell cytosol, where they are gradually oxidised to produce ATP molecules[896]. An adult body can store approximately 2,000 calories of energy in glycogen, enough for about two hours of vigorous exercise. This stored energy also supports building body parts, muscles, bones, and blood.

The brain consumes about 20% of the body's daily energy[897]. Everyday activities such as gardening, walking, talking, typing, and swimming, burn substantial amounts of energy. Unused calories are converted into fat and stored, typically around the belly. Despite its appearance, body fat stores a lot of energy in lipid molecules.

In summary, we propose that all living and nonliving entities serve as potential energy silos to delay the universe's journey towards the absolute true vacuum state - the motionless, vibrationless, dark, and freezing cold state known as *death* – thus, avoiding assimilation back into the Substrate.

In this chapter, we also emphasized that the physics of Substrate space is different from quantum physics, just as the latter differs from Newtonian physics. The readers of this book are encouraged to integrate the gravity-antigravity-dominated pre-quantum physics, the Substrate, into both quantum and classical physics as it would be an alternative approach for developing a unified theory of everything. It only needs to assume that negative (repelling) mass and energy exist until their existence is demonstrated in future.

Next, we explore the motivation behind the survival instinct of every living being and why every living being is designed to persist, drawing on Richard Dawkins' concept of the selfish or immortal gene.

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[896]. Bob Murray and Christine Rosenbloom, 2018. Fundamentals of glycogen metabolism for coaches and athletes. Nutr Rev. 2018 Apr; 76(4): 243–259. DOI: 10.1093/nutrit/nuy001, PMCID: PMC6019055, PMID: 29444266 . https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6019055/

[897] https://qbi.uq.edu.au/brain/nature-discovery/how-your-brain-makes-and-uses-energy .

CHAPTER XII: WHY DO LIVING THINGS WANT TO STAY ALIVE?

"The purpose of life is to keep the genes alive. We are survival machines — robot vehicles blindly programmed to preserve the selfish molecules known as genes... If our purpose is to preserve genes, what is the purpose of the genes? If self-preservation is their purpose, where did this purpose come from? Where did the information in the genes come from that promotes this purposeful activity?" said Charles H. Lineweaver,[898] citing Richard Dawkins[899]. In this quote, Lineweaver of ANU, Australia is seeking to understand the origins of life itself, and its purpose.

We answer these questions by proposing that life exists because it serves as the universe's best defence against a quick death. Life emerged as an inheritance from the universe's inherent desire[900] to survive. Our assertion is that the universe achieves this through reducing entropy and creating orderly structures. Every matter, whether living or nonliving, is an orderly structure; a potential energy storage silo that serves to delay the universe from reaching a quick end.

Other scientists offer a different perspective, such as Arto and Erkki Annila (2008)[901] who argued that *"when molecules make cells and cells make tissues, organs, and fully functional increasingly complex organisms they consume increasingly more free energy hence accordingly, their entropy increases, not decreases. This increasingly hierarchical organisation seems to have emerged and developed because they provide paths for increasing energy flows".*

According to their view, the driving force behind life is the transition from inanimate to animate, which increases the overall entropy of the universe (the opposite of what we have proposed above). They suggest that complex organisms with cellular metabolism disperse energy throughout their structures and into the environment.

Others[902] have highlighted the food chain within ecosystems as another example of a mechanism which transfers energy on a larger scale, increasing entropy and striving towards chemical equilibrium. Yes, the increase in entropy may seem the outcome but not the purpose of the existence of the universe.

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[898] Charles H. Lineweaver, Increasingly Overlapping Magisteria of Science and Religion, http://www.mso.anu.edu.au/~charley/papers/IncreasinglyOverlappingMagisteria9.pdf

[899] https://archive.org/details/the-selfish-gene-r.-dawkins-1976-ww/The%20Selfish%20Gene%20-%20R.%20Dawkins%20%281976%29%20WW Richard Dawkins "The Selfish Gene" 1976.

[900] Obviously not consciously as explained later.

[901] Arto Annila and Erkki Annila (2008). Why did life emerge? International Journal of Astrobiology 7 (3 & 4): 293–300 Printed in the United Kingdom, Cambridge University Press doi:10.1017/S1473550408004308.

[902] https://phys.org/news/2008-12-life.html

If the above perspectives hold true, one might conclude that the universe must be suicidal! Numerous indicators suggest that the universe is intricately engineered to sustain life and perpetuate its genetic continuity. While entropy may increase in terms of degrees of freedom (or number of variables) and the number of components (reaction products), these processes do not introduce any new energy beyond what the Big Bang initially supplied. It seems very unlikely that the universe would produce selfish genes only for their demise.

Earth's terrain is covered with oceans, lakes, vegetation, and wildlife - all of which are created by absorbed or converted energy. Oceans and lakes foster abundant life, ranging from algae, protozoa, and fish of all shapes and sizes. These organisms all consume energy from their surroundings. Once formed, a rock or mineral cannot store more energy than it originally possessed. In contrast, living beings possess the capacity to store energy continuously through replication and population growth. They are the most advanced energy storage silos that have ever been created on Earth.

Living beings hold an advantage over inanimate matter: they start small and grow larger, gradually storing more potential energy. When they die, their bodies become food for macro and microorganisms. The flesh provides energy for bacteria and other flesh-consuming organisms, while what remains - skeletons, teeth, and skulls – are durable structures mainly made of collagens, calcium phosphate, and calcium carbonate. These materials continue to store energy for hundreds of years, eventually transforming into fossils if replaced by silica and other minerals. Ash from cremated remains becomes a part of the soil[903]. Throughout these processes, no new energy is created or lost – it simply changes form, transforming from one state to another. Thus, both living and non-living entities serve as silos for storing energy and as vehicles for facilitating this transformation.

While living beings are potential energy silos, their existence is temporary. It is this impermanence which drives them to reproduce and perpetuate themselves. As we age, we shrink and become less efficient as storage silos. However, throughout our lives, we replace ourselves with our newborns. This system of genetic inheritance ensures that the extraction of energy from the environment continues and even increases over time. While an increase in numbers may appear to mean an increase in entropy, it actually signifies the creation of more orderly (low entropy) structures.

Plants were the first organisms to convert starlight into food, paving the way for the development of increasingly complex and sophisticated life forms capable of storing more and more potential energy. The higher the organism in the biological hierarchy, the greater its capacity to store

[903] Cremation is meddling with the food chain and adding thermal energy and smoke to the environment. It deprives the bacteria and insects from their food.

potential energy. The universe had to create increasingly complex structures to absorb more kinetic energy from its surroundings.

On Earth, chlorophyll molecules evolved to convert the Sun's energy into orderly structures like trees and vegetation, millions of years ago. Geological processes buried this vegetation underground over time, where it compressed into even more orderly structures like coal and lignite, estimated to amount to between 1 - 4 trillion tons of carbon[904].

The digestive system of a cow converts grass, an orderly solid, into nutrients and methane gas which (eventually) breaks down into carbon dioxide[905]. Plants then consume the carbon dioxide through photosynthesis, releasing oxygen, creating a closed and balanced recycling system on Earth.

The methane generated by cows would be negligible in the wild, but humans have domesticated over one billion[906] cows worldwide. This has significantly increased methane emissions. In the wild, cow populations would be limited by natural predators higher up in the food chain. Similarly, rabbits would dominate the planet if not for foxes. This illustrates the natural hierarchy, or pecking order, on Earth.

Living beings excrete liquid and solid waste from the food they consume and the water they drink. They also emit heat through doing various activities. However, they do not create or add any new energy into their environment. Rather, they act as distributors or converters of the energy they consume for their existence. They simply extract energy from the Sun and other stored potential energy sources such as vegetables, fruit, meat, and drinks. The digestion of this food sustains bodily functions and facilitates work. The by-products of these processes are excreted as solid, liquid, and gaseous waste. These byproducts are also potential energy storage silos in their own right.

Grass is a storage silo for sunlight energy, originating from hydrogen burning on the Sun’s surface. Hydrogen was created during the Big Bang. When a cow eats grass, it absorbs some of this energy, growing fatter and developing bones, muscles, and meat. Waste from digestion exits the cow's rear end, with no new energy generated in the process. Methane gas produced by burping cows comes from digesting grass as they produce milk and meat for human consumption. Milk and meat are examples of semi to fully ordered (low entropy) structures.

A living body acts as an energy storage silo, supplying energy for both mental and physical activities as needed. Our bodily functions, including brain function, heart function, lung activity, nervous

[904] https://www.agci.org/earth-systems/biosphere
[905] Lightning strikes and forest fires set methane burn to give off carbon dioxide and water.
[906] https://www.statista.com/statistics/263979/global-cattle-population-since-1990/

system responses, and muscle cell function, draw from these stored energy sources, primarily from the food we eat.

However, every living being has a limited life span - an *expiry date* that cannot be avoided, at least for now. Death is a natural process which unfolds as our bodies go through various aging processes. The speed and extent of these processes can vary, influenced by the duration and nature of stressors and diseases encountered throughout life.

As all living beings age, the effects of wear and tear, neglect, and misuse take their toll. Critical biological processes essential for life begin to malfunction, leading to the onset of diseases and ultimately, death. Shortly after death, cells undergo necrosis, a biological process known as the "*death cascade*", where they swell with water and break apart through lysing[907]. This triggers the activation of numerous hydrolytic enzymes which accelerate catabolic reactions and initiate auto-digestion.

For the survival of the universe, the quantity of degrees of freedom or components within a system is not as important as the amount of potential energy that can be stored and maintained in an object. Even if energy transformations generate heat or waste, these by-products are often converted into other forms of matter and stored in other silos through the ecosystem's recycling processes. The biosphere operates as a dynamic system: waste is broken down within it, and the hydrosphere washes away excesses (unless they occur in overwhelming amounts).

XII.1. Why Every Living Being Wants To Exist?

The most compelling answer to the question of why every living being wants to exist is provided by Richard Dawkins. An eminent British scientist, Dawkins suggests that genes, embedded within the chromosomes[908] in a cell's nucleus, are driven to survive. He metaphorically refers to these genes as "selfish" or "immortal," attributing to them an algorithm - an information blueprint which keeps the cells alive[909].

According to Dawkins, this genetic programming seeks to prolong life and delay death for as long as possible, guiding cells to form tissues, organs, and complex organisms capable of activities like walking, talking, flying, and swimming.

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[907] Brown K, Awan NA, Le PH, et al. Histology, Cell Death. In: StatPearls. Treasure Island (FL): StatPearls Publishing, 2020.

[908] A cell's nucleus contains 23 pairs of chromosomes. A chromosome contains many genes. A gene is a segment of DNA (deoxyribonucleic acid), a long coiled double helix-like spiralling staircase - that provides the code to construct a protein or RNA molecule. https://www.msdmanuals.com/en-au/home/fundamentals/generics/genes-and-chromosomes

[909] Let us clarify before going further though: Genes are selfish but this is not a conscious selfishness; a gene or a group of genes does not have a brain or mind to make decisions.

In nearly every living being exists an in-built routine: birth, growth, reproduction, aging, and death. This routine, Dawkins argues, is not a predetermined expiration date imposed on cells, but rather a genetic knowledge encoded in the sequencing of organic molecules. This knowledge is inheritable, passed down through generations.

Genes appear to have ingeniously recognised the impermanence of the body: it is susceptible to wear and tear, mutations, and the effects of aging. As the body is so vulnerable, it is not an ideal vessel for perpetuating genetic knowledge. Instead, genes have found it much more efficient to store this critical information within cells. The capacity for reproduction is not specific to humans, but it is a fundamental characteristic shared by all living organisms on Earth.

Living cells are not forever - not immortal. Eventually, they perish along with the body they constitute. To ensure their survival and to avoid the rapid extinction of their lineage, selfish genes have developed a survival mechanism: the hereditary mechanism encoded within the genes of every species. This genetic code carries not only survival instincts but all information from the earliest, most primitive organisms to the most advanced living beings across generations.

For example, in humans, this mechanism of inheritance enables them to pass on their traits to their children. In doing so, our selfish genes ensure their continuity through our children – even after we ourselves have ceased to exist.

It is mind boggling how every living organism, from a single cell to the most complex human beings, is so cleverly designed, astoundingly built and miraculously operate. Their primary function is to ensure the transmission of their hereditary material in their genes to their offspring, thereby securing their continuity and existence across generations.

Despite being thoughtless inorganic molecular complexes, genes possess the remarkable ability to make copies of themselves and pass on hereditary information to their offspring. According to Dawkins, living bodies merely serve as vehicles to propagate these genes.[910] He argues that genes are not affected by the bodies they inhabit as they pass through generations, describing life as "*just bytes and bytes and bytes of digital information*"..... *"All living beings are only ephemeral vehicles to convey their genes to the next vessel".* Thus, genes, or selfish DNA, are driven to achieve immortality in their perpetual quest for survival, rather than the mortal bodies they inhabit.

Dawkins explains that life originated from a primordial soup where complex organic molecules formed from carbon, hydrogen, oxygen, and nitrogen. Genes emerged within this context, shaping

[910] Dawkins, R. (2016). The Selfish Gene: 40th Anniversary edition (4th ed). Oxford University Press. ISBN 0191093076

life as we know it today. Dawkins succinctly states, *"We are nothing more in the universe than being mere carriers of some double-helix structures".*

According to Dawkins, the process of natural selection in evolution does not prioritise the security of the entire species, community, or group. Instead, its focus is on ensuring the security of the individual carrying the precious genes that evolved over millions, if not billions, of years. Without the genes, there would be no species, communities, groups, or life itself.

In order for a group or species to survive, individuals must behave in ways that promote their genetic self-interest. This involves forming alliances and ensuring that their genes are passed onto future generations. Dawkins describes genes as inherently selfish entities which compete for their own survival. There are many examples in Dawkins' must-read book, where he states that *"Genes are competing directly with their alleles for survival, since their alleles in the gene pool are rivals for their slot on the chromosomes of future generations. Any gene that behaves in such a way as to increase its own survival chances in the gene pool at the expense of its alleles*"[911].

This is all good, but it still does not explain why genes have an inherent drive to survive. What motivates this urge for existence? Is evolution protecting a process which emerged accidentally, or from random events? Why is genetic code so strongly embedded and persistent? Did it originate in chaos, a marvel of biological evolution? Genes do not have brains or consciousness – they are merely protein and lipid molecules. Yet, they exhibit a profound determination to preserve their existence. While biological evolution aligns and perpetuates successful traits, the underlying reasons may be more complex - is it really that simple?

Selfishness and the urge to persist is a common motive amongst humanity and every other living being. What drives all life forms to want to survive? The answer lies in LUCA, the Last Universal Common Ancestor from which all biological evolution originates.

The survival allele imprinted in LUCA's first cell proved to be beneficial for the continuity of the cell. Therefore, it remained and persisted across generations, passing to every other living being over time. How did this primitive cell determine what was beneficial for its survival? Why did it develop a selfish drive for existence at the time when there were no competitors? What prompted this cell to prioritise survival over everything else? Did it test all other options and decide this was best? Did it even have a decision-making and elimination mechanism? Understanding why LUCA chose survival could shed light on the fundamental motivations behind the persistence of life.

[911] https://www.biologyonline.com/articles/selfish-gene-selfish-to-persist

To these questions, my tentative answer is to say that it may not be the genes of the first cell that wanted to survive, but the components (atoms) which make the genes, DNA, and cell, that wanted to survive.

In the next section, we claimed that the real selfish entities striving for survival are quarks and leptons - the most elementary subatomic particles as far as we know now. These particles form protons, neutrons, atoms, molecules, proteins, lipids, and everything else in the universe. They are the most elementary potential energy silos, essential for the universe to delay its eventual demise, and ensure its own survival.

XII.2. The Universe Wants to Stay Alive – Just Like Living Beings

As far as we know quarks and leptons were the first real, therefore vibrating subatomic particles (see Chapter VI.8). They were formed in the early moments of the Big Bang from the Substrate, which was vibrationless, cold, dark, timeless, and motionless. Quarks and leptons are the simplest building blocks of everything in our universe, including *selfish genes* and DNAs. We propose that those simplest building blocks do not wish to lose their vibration. It is almost as if they know that if they stop vibrating, everything will fall apart and they will revert to the Substrate.

All living and nonliving things are made from atoms. Atoms themselves are made mainly of top and bottom quarks, and electrons (a lepton) and the forces acting on them. These particles were all created at the Big Bang. These simplest of quanta built the whole universe from atoms and give the atoms their intrinsic properties like frequency, mass, spin, and charge. Through these characteristics, atoms respond to various types of force fields. Each of these characteristics constitutes information that defines behaviour.

Among these properties, the one that has the potential to communicate with its surroundings is vibration. We know that in our universe, each quantum particle (entity) vibrates at its own specific frequency, and that frequency is its most distinct characteristic. The vibrations, or frequencies, of quanta serve as their unique fingerprints, and they are possibly the only information-transmitting tool the quanta possess. Vibration and temperature are directly related to each other. In hot environments, atoms vibrate faster, while in cold environments, atoms vibrate slower.

Then the question can be asked: How do these vibrations transmit their information? We propose that information transmission is mediated by the sea of repelling particles when they generate a unique disturbance in the sea of repelling particles. This is somewhat similar to how bees communicate with each other; bees use their wings to generate vibrations at different frequencies.

They do this by flapping their wings at faster or slower rates, which changes the air pressure. Watch Animal Einsteins Episode 2 from YouTube X8J5iyg.

The disturbance created by the positive mass resonates with the anti-gravitating sea of particles and is transmitted as information over long distances, possibly through quantum entanglement protocols assumedly mediated by the anti-gravitating sea, which is a superfluid state.

So, quarks and leptons do not have intelligence nor any sort of consciousness, but they have a characteristic frequency. The matter that makes up our cells and absolutely everything else consists of clusters of vibrating atoms. They inherently possess the information that vibration is important and that if it stops, the result will be the vibrationless zero-bit state.

All this may sound as if the universe has some intelligence and knows what it is doing, almost as if it is aware that it is heading towards its demise, so that it can take measures to prevent it.

In the next chapter, we asked: Does this mean there is a conscious, decision-making process in play in Nature? Here's the spoiler: No, there is no puppet master nor any intelligence pulling the strings of Nature behind the scenes. Let me explain.

CHAPTER XIII. DOES NATURE KNOW WHAT IT IS DOING?

As if the universe somehow "knows" it is destined to an inevitable end, it builds increasingly better and bigger potential energy silos to delay the runaway kinetic energy ordeal and consequences of expansion. This may sound like an action that requires intelligence, but quanta do not possess intelligence, consciousness, algorithms, or templates; they simply follow their one intrinsic property, which is to vibrate."

If there was no Big Bang, there would be no vibrating quanta, no fundamental particles, no atoms, and none of the four fundamental forces. There would only be a dark, timeless, motionless, and vibrationless Substrate.

The operation of the universe is not part of someone's plan. It is neither orchestrated by one of the gods, an intelligent being, nor a conscious mind granted to Nature. Rather, it is the result of Nature's own processes. These do not involve consciousness nor intentionality.

We subscribe to the idea which says life and intelligence emerged on Earth through a combination of chance events, genetic mutations and natural selection, rather than as a deliberate goal or purpose. Nature does not have a conscious purpose or goal. Instead, its processes operate on a much larger timescale. When the right environment conditions, such as the right temperature, pressure and components exist, the physical, chemical, electrical properties of atoms come into action to build randomly new molecules. These molecules are retained if they are useful in building a bigger and better system if not then they are discarded. In this sense, Nature simply exists and reacts to its surroundings in a constantly changing and evolving way. It does this without any ultimate direction or plan: just like a loose sheet of paper moving around unpredictably in a gusty wind.

From this unpredictability, a set of rules and patterns have evolved and persisted over time. These patterns and rules guide the behaviour of animals, plants, and other natural phenomena, allowing Nature to adjust and adapt to changes in its surroundings. As chaotic or random as it may seem, patterns do emerge when given enough time.

XIII.1. IT IS ALL NATURAL AND OUT OF CHAOS

The Chaos Theory of the Universe argues that everything we see is the product of a chaotic beginning: the hot Big Bang. It states that everything we see around us was built over long years of trial and error, elimination using self-assembly and self-organisation processes, and in fractal patterns. This scenario assumes that everything is a creation of an evolving process with no pre-

planning, architect's design, nor builder's construction: it is simply all out of chaos and the result of random events. This includes biological evolution and the rise of living beings on Earth.

Chaos is the opposite of orderliness: it implies disorder and unpredictability[912]. Chaos affected the universe following the Big Bang. From the disorder and chaotic beginning, orderly structures such as stars, suns, galaxies, black holes, planets, moons, and living beings have emerged.

In this scenario, none of these structures required a designer or a builder. They simply happened as a result of the physical, chemical, electrostatic and magnetic properties of atoms and molecules. Forces such as the four fundamental forces, plus those Van der Waal[913], capillary[914], and entropic[915] forces, acted upon them.

The universe is not aware of whether all the stars, galaxies, plants, and animals are potential energy silos to delay its demise. They simply happen along the way because they are made out of quanta with real mass, and every quanta with real mass attracts each other.

Chaos is the science of the nonlinear and the unpredictable: expect the unexpected. Chaos theory deals with things that are effectively impossible to predict or control. This is the opposite of traditional science, which deals with predictable outcomes like gravity, electricity, and chemical reactions. Unpredictable phenomena such as turbulence, weather, the stock market, and the workings of our brains are in the domain of chaos theory.

Chaos theory suggests that; although it may take a very long time, events that occur in one place can eventually have an effect far away, because everything is interconnected. The classic example[916] of this the butterfly effect: the idea that a small butterfly flapping its wings could hypothetically cause a typhoon somewhere else. In a deeply interconnected system like the universe, one small occurrence can cause a cascade effect, which can eventually influence a much larger complex system.

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[912] Is nature really chaotic and fractal? https://cosmosmagazine.com/science/physics/is-nature-really-chaotic-and-fractal-or-did-we-just-imagine-it/

[913] Van der Waals forces are weak electrostatic forces that attract neutral molecules to one another. Particles in liquid or air vibrate and move constantly via the process known as Brownian motion. https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/van-der-waals-force

[914] The process of a liquid flowing in a narrow space without the assistance of, or even in opposition to, any external forces like gravity. https://en.wikipedia.org/wiki/Capillary_action

[915] Wikipedia describes entropic force as force acting in a system resulting from the entire system's statistical tendency to increase its entropy, rather than from a particular underlying force on the atomic scale. https://en.wikipedia.org/wiki/Entropic_force

[916] https://en.wikipedia.org/wiki/Chaos_theory

Given the right conditions, order can arise from disorderly chaos[917]. Chaotic systems are sensitive to any slight change to their initial conditions. In a chaotic environment, a small change in the initial conditions leads to drastic changes in the results. The stock market is a good example of this: the value of a stock rises or falls, and investors react to this change by either buying or selling that stock. Their actions affect the price of the stock which causes it to rise or fall chaotically, not only in Wall Street, but in other markets around the world - akin to the connectedness of the universe.

Chaos theory states that within apparent randomness of chaotic complex systems, there are underlying patterns, interconnection, constant feedback loops, repetition, self-similarity, fractals, and self-organisation[918].

In a chaotic environment like the one created by the Big Bang, only quarks, leptons and possibly the fundamental forces, existed initially[919]. When the conditions such as temperature were right, quarks with an affinity for each other started combining to form protons and neutrons, which then captured nearby electrons (leptons) whizzing around.

There is no brain, architect, designer, nor coded order in the creation of the simplest hydrogen isotopes: protium, deuterium, and tritium. These isotopes fuse to form helium, not by design or desire, but because the intrinsic properties, high temperature, and correct pressure make it inevitable. Under such conditions, they will always fuse and create helium atoms. In this way, the lighter elements of the periodic table formed one by one.

Similarly, all gravitating massive objects and energy storage silos will form when physical, chemical and environmental conditions are conducive to the reactions, not because of any intelligent natural or supernatural intervention. If the Substrate develops a sore spot, a bubble will inflate and grow exponentially due to a variation imposed on the Substrate: not because a puppet master pulled the strings behind the scenes.

Chaos theory suggests that even a deterministic system[920] may produce long-term unpredictable results. The unpredictable behaviour of chaotic systems is the result of nonlinearity and sensitivity to initial conditions. Nonlinear processes do not solely shape the physical world. Human

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[917] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/chaos-theory

[918] https://en.wikipedia.org/wiki/Chaos_theory

[919] However, let us be candid and point out that the level of our science has no established idea about how the fundamental particles came to existence and gained their particular charge, spin and mass properties, and established selective relationships with those the four force fields, electromagnetism, gravity, weak and strong nuclear forces.

[920] Deterministic means believing that everything that happens must happen as it does, and could not have happened any other way, Deterministic systems operate according to a predetermined set of rules. A good example of a deterministic system is a computer program. A deterministic system always returns the same output or reaches the same future state.

interference often creates nonlinear systems which can show chaotic behaviour[921], such as greenhouse gas emissions leading to climate change.

Chaos theory recognises that seemingly simple physical systems which obey deterministic laws, can behave unpredictably (op. cit.). For example, heat convection, irregularities in heartbeat, population dynamics, chemical reactions, plasma physics, and the motion of star clusters all exhibit intrinsic unpredictability[922]. A simple example is the movement of a ball in a pinball machine. Although its movement is governed by the laws of gravity and elastic rebounding, the final position of the ball is unpredictable (op. cit.).

Chaos theory has applications in many disciplines including astrophysics, sociology, mathematics, physics, biology, geology, neuroscience, meteorology, economics, politics, finance, many branches of engineering, philosophy, topology, robotics, and anthropology[923].

SELF-ASSEMBLY AND SELF-ORGANISATION

These processes create organised structures or patterns from a disordered, chaotic system without an external interference[924]. Both terms describe how collective order arises from dynamic small-scale interactions. Thermodynamically, self-organisation is a non-equilibrium process.

Self-organisation theory explains how complex systems in the natural world can spontaneously organise and evolve over time, without external input. The theory applies to a variety of phenomena, including the development of biological organisms and ecosystems, social behaviour in human communities, and the emergence of economic and political systems.

The key principle of self-organisation theory is that complex systems can evolve through the interactions among their constituent parts, which may follow simple rules or exhibit some randomness. These interactions can lead to emergent properties and patterns that are not present in the individual components, but arise from their collective behaviour. For example, the self-organisation of ants into colonies is driven by interactions between individual ants, which follow basic rules of communication and task allocation, resulting in the emergence of complex social structures and behaviours.

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[921] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/chaos-theory
[922] https://www.britannica.com/science/chaos-theory
[923] https://en.wikipedia.org/wiki/Chaos_theory
[924] https://en.wikipedia.org/wiki/Self-assembly

Crystal formation, convection in liquids or gases, phase transitions, protein folding, formation of cell membranes, and weather patterns, are all examples of how energy can drive the organisation of matter into specific patterns and structures.

Self-assembly theory explains how complex structures, like those found in biological organisms, can spontaneously emerge from simpler components. It describes a process where molecules or other basic building blocks bond to form larger structures or entities without any external guidance or control.

This process is driven by the intrinsic properties of the building blocks, such as their shape, size, charge, and polarity. These characteristics influence how the blocks interact with each other, leading them into specific arrangements which give rise to specific structures with unique properties.

Self-assembly plays a crucial role in biology, particularly in the formation of complex structures like proteins, membranes, and DNA strands. These molecules are composed of smaller subunits like amino acids and nucleic acids, which organise themselves into specific shapes and structures, based on their chemical properties and interactions.

Other examples include the formation of the lipid bilayer, protein folding, DNA packaging, assembly of virus capsid, and the formation of supra-molecular structures. These processes occur spontaneously through favourable interactions between building blocks such as the hydrophobic tails and hydrophilic heads of phospholipids, amino acid residues in proteins, and non-covalent interactions between DNA and histone proteins.

Self-assembly is a spontaneous process which leads to an ordered state as a system approaches equilibrium, thereby reducing its free energy. It involves the organisation of molecular units into structured patterns through non-covalent[925] interactions, driven by specific local interactions among the components. The process is both spontaneous and reversible, resulting in the formation of ordered structures without the need for external guidance.

Self-assembly typically occurs between weakly-interacting species. This organisation may be transferred to strongly-bound covalent systems, to form highly organised covalent molecules. Self-assembled nano-structures result from the ordering and aggregation of individual nano-scale objects, guided by physical principles.

[925] In chemistry, a covalent bond refers to the interatomic binding which results from the sharing of an electron pair between two atoms. The binding arises from the electrostatic attraction of their nuclei to the same electrons.

Entropy maximisation is one such physical principle which drives self-assembly[926]. Entropy is conventionally associated with disorder. However, under suitable conditions, entropy can drive nano-scale objects to self-assemble into target structures in a controllable way. For example, in a field-directed assembly using magnetic fields, materials of macroscopic size can self-assemble (op. cit.).

Properties which control self-assembly are weak interactions, thermodynamic stability, and sensitivity to perturbations exerted by the external environment. Self-assembly is also influenced by external parameters, which can make synthesis rather complex because of the need to control many variables. Yet, an advantage of self-assembly is that a large variety of shapes and functions on many length scales can be obtained (op. cit.).

For self-assembly to occur without the intervention of external forces, the process must result in a decrease in Gibbs free energy, ideally leading to a lower or negative value[927]. Self-assembled structures are therefore more thermodynamically stable than their unassembled components (op. cit.). The fundamental condition required for nano-scale building blocks to self-assemble into an ordered structure is the simultaneous presence of long-range repulsive and short-range attractive forces (op. cit.).

Some notable examples of self-assembly include the formation of molecular crystals, hydrogels, colloids, lipid bi-layers, and some polymers (op. cit.). In developmental biology, pattern formation generates complex organisations which give a cell its identity in space and time. The role of genes in pattern formation is an aspect of morphogenesis - the creation of diverse anatomies from similar genes – which is now being explored by evolutionary developmental biologists (op. cit.).

FRACTAL THEORY

Fractal theory describes the study of fractals: structures or shapes which appear similar at different levels of magnification. This interdisciplinary field of study draws upon mathematics, computer science, and physics.

Fractals are figures made of recurring shapes, patterns, or curves at progressively smaller shapes and sizes. A fractal is a never-ending, infinitely complex, and repeats the same pattern over and over, driven by a rule or formula involving a finite number of steps.

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[926] https://en.wikipedia.org/wiki/Chaos_theory
https://en.wikipedia.org/wiki/Self-assembly

[927] A process or a reaction takes place spontaneously and without any external energy input if the value of the ΔG (Gibbs free energy) is negative or zero. Reactions with positive (+) ΔG need an external input of energy in order to take place, therefore they are not spontaneous.

Like fractals, cells create tissues by repeating themselves. Organs like lungs, leaves or branches of a tree, all result from nonlinearities of charge interaction and display fractal and chaotic dynamics.

Fractals can also be created through mathematical equations and computer algorithms. One of the defining characteristics of a fractal is its self-similarity: the structure or shape of the fractal looks the same when viewed at different scales. This property is known as scale invariance, a fundamental concept of fractal theory.

In the famous Mandelbrot set, self-similarity repeats itself over and over. Each pattern is made up of smaller copies of itself, and those smaller copies are made up of even smaller copies and so on[928]. Our lungs are fractal-like in appearance. When we breathe in, our lungs expand. Air fills 500 million tiny alveoli, each a fraction of a millimetre across. As we exhale, millions of tiny breaths merge effortlessly through increasingly larger airways, into one ultimate breath to be exhaled[929]. The lungs are designed[930] in such a way that each airway branches out in exact proportions, making each branch a smaller replica of the previous branch. The only difference between the lungs of a small child and those of an adult is how many times the airways branch. The circulatory system of blood vessels and veins in our bodies, just like the veins of a leaf, shows clear fractal structure.

Fractals are the demonstration of Nature repeating itself. Trees, ferns, landscapes, snail shells, and river networks all do look-like smaller versions of themselves. The central trunk of a tree forks into two or more branches, which themselves fork again and again into increasingly thinner branches, before finally terminating in tiny twigs. Leonardo Da Vinci observed[931] that in tree branching, the total cross-sectional area of all branches is preserved. Going from trunk to twigs, the number of branches and their diameter change with each branching, but the total thickness of all the branches bundled together stays the same (op. cit.). Da Vinci's observation implies scale invariance: for every branch of a certain radius, there are four downstream branches with half that radius (op. cit.).

Fractals represent partly random or chaotic phenomena. Nonlinear and unpredictable chaotic phenomena are often described by fractals, capturing the infinite complexity of Nature. Many natural objects exhibit fractal properties. Recognising the chaotic and fractal-like nature of our world can give us an understanding of the complex dynamics of the atmosphere, for example the movement of clouds, ecosystems like trees, and landscapes like rivers[932].

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928 Michael Lucy 2021. Do fractals exist in nature? https://cosmosmagazine.com/science/mathematics/fractals-in-nature/

929 The mathematics of scale. 27 May 2019. https://cosmosmagazine.com/science/mathematics/mathematics-of-scale-big-small-and-everything-in-between/

930 Designed by biological evolution, not by an intelligent being or supernatural power.

931 https://cosmosmagazine.com/science/mathematics/mathematics-of-scale-big-small-and-everything-in-between/

932 https://cosmosmagazine.com/science/mathematics/fractals-in-nature/

Fractals are useful in modelling crystal structures, such as the growth of snowflakes, galaxy formation, and star structures. There are many other examples of fractal patterns, such as rivers, coastlines, mountains, clouds, seashells, and hurricanes. etc. Fractals such as the Mandelbrot Set can be generated by mathematical equations and demonstrated by iterative programs[933].

Amanda Gefter (2007)[934] suggests that even the universe is a fractal. Gefter points out that views on the structure of the universe are changing from isotropic (smooth or uniform) to non-isotropic. There is now evidence supporting the universe being non-isotropic, for example, some galaxies are moving away from each other at different rates. Gefter mentions that galaxies form a structure that is not uniform, but at least *"some parts of it have lots of matter, others don't, but the matter always takes the same pattern, in large and small versions".* This implies that the universe is fractal in its nature.

Chris King[935] from the University of Auckland, New Zealand, gives examples from the biosphere. He explains how tissues, organelles, organs like skin, and assemblies made of cells, all have fractal structures and display chaotic dynamics. This is due to the non-linearity in chemical bonding. He points out that these fractal structures are similar to those arising from a computer-generated Mandelbrot set[936].

Recently, emerging theories suggest that every quantum, atom, and elementary particle may store bits of information, which appears to us as intelligence. Although still relatively new and controversial, this idea could significantly reshape our understanding of information and its relationship to the physical world around us. It could even offer a major alternative to the Chaos Theory.

XIII.2. IT IS ALL FROM BITS

John Archibald Wheeler suggests that the universe is made up of particles, fields, and information. He proposes that everything emanates from the information inherent within it, and coined the phrase *"It from bit."*[937]

This phrase represents the convergence of the physical and digital worlds - where lines between the two are becoming increasingly blurred. As technology continues to advance, it is likely to

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933 https://fractalfoundation.org/resources/what-are-fractals

934 Amanda Gefter (2007) https://www.newscientist.com/article/mg19325941-600-is-the-universe-a-fractal/

935 http://www.fractal.org/Bewustzijns-Besturings-Model/Chris-King-fractal-universe.pdf

936 https://en.wikipedia.org/wiki/Mandelbrot_set

937 J. A. Wheeler, "Information, physics, quantum: The search for links," in *Proceedings of 3rd International Symposium Foundations of Quantum Mechanics* (Physical Society of Japan, Tokyo, 1989), pp. 354–368.

become even more relevant and applicable to our understanding of the meaning of our existence. There are already suggestions[938] that every quanta, atom, and elementary particle, stores bits of information[939] from their interactions with other atoms and particles. They do so by flipping the bits into a new arrangement. If this is correct, this could offer answers to questions about the origins of survival instincts in both the universe and living beings.

We know that quanta - whether an electron, proton, nucleus, fundamental particle, neutrino or an antimatter particle - all have their own intrinsic properties. These include characteristics such as spins, charge, mass, frequency/vibration, energy levels, electric charges, and magnetic properties. Through these characteristics, quanta respond to gravity, electromagnetic, weak and strong nuclear force fields. Each property is information which defines what that particular particle always does under the right conditions. Atoms and elementary particles do not store bits of information like a computer or DNA does,[940] but their properties and characteristics can serve as a medium to represent information.

In quantum mechanics, bits of information, referred to as qubits, can be encoded through the states of an atom or elementary particle. For example, the spin of a particle can represent a 0 or 1 in binary code. In classical physics, atoms and particles can store information through their chemical, physical, magnetic, and electrical properties. The number of electrons in an atom's outer shell can be used to store data. We can interpret these properties as information by assigning a bit code: 0 for a clockwise spin and 1 for a counter-clockwise spin. The important point is that we, as observers, assign these 0s and 1s arbitrarily, not the atoms and particles themselves.

The information content associated with matter - and by extension, the universe - has long been the subject of scientific debate[941]. In 1961, Landauer[942] was the first to propose a link between thermodynamics and information, demonstrating that digital information is not just an abstract mathematical entity but it, is in fact, physical[943]. This idea was further developed in 2007 by Seth Lloyd[944], a Professor of Mechanical Engineering at MIT.

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[938] I will leave it to you to decide whether it is intuitive or unintuitive.

[939] The unit of information is a bit (binary digit). In computer science a bit is denoted by electrical value as zeros (OFF) and ones (ON).

[940] However, let us be open minded and say these are early days and we may be surprised to know in the not-too-distant future flipping a set of bits (atomic properties) may produce storable and retrievable information.

[941] Melvin M. Vopsona 19 October 2021. Estimation of the information contained in the visible matter of the universe: AIP Advances 11, 105317 (2021); doi: 10.1063/5.0064475 https://aip.scitation.org/doi/pdf/10.1063/5.0064475

[942] R. Landauer, "Irreversibility and heat generation in the computing process," IBM J. Res. Dev. 5(3), 183–191 (1961).

[943] Landauer, "Wanted: A physically possible theory of physics," IEEE Spectrum 4(9), 105–109 (1967).

[944] Seth Lloyd, 2007. Programming the Universe: A Quantum Computer Scientist takes on the Cosmos, ISBN-13: 978-1400033867; 256 pages.
S. Lloyd, "Computational capacity of the universe," Phys. Rev. Lett. 88, 237901 (2002);

In his book *Programming the Universe: A Quantum Computer Scientist Takes on the Cosmos,* Lloyd suggests that the universe is made of bits of information, with every electron, atom, and molecule, registering these bits. According to Lloyd, particle interactions convey not only energy but also information. He states: *"Every atom and elementary particle stores bits of information from every collision between those atoms and particles by flipping the bits into a new arrangement and making complex systems".* In his view, *"particles not only collide, they compute. The entire universe computes its own dynamical evolution".* Lloyd argues that this stored information is what allows the universe to fight back, avoid its own demise, and remain in existence.

Dr. Melvin Vopson,[945] a physicist, has proposed a relatively new concept in information science. He suggests that information has its own mass. This idea stems from the intrinsic connection between information and energy, one of the fundamental principles of thermodynamics. According to Dr. Vopson, information can be regarded as a physical quantity, much like energy or mass. He proposes that every piece of information, whether a single bit or a more complex data set, has a corresponding mass value. This is because information is fundamentally linked to energy, which implies that energy has mass, according to Einstein's famous equation $E=mc^2$.

In essence, the more information a system contains, the more energy is required to describe it. Experiments have supported this idea by demonstrating that erasing information from a computer's memory can cause a measurable decrease in the computer's mass.

Dr. Vopson published a number of papers suggesting that information is physical and has mass. According to him, all elementary particles store information about themselves, just like DNA does (op.cit.). Vopson labelled this the fifth form of matter (alongside solids, liquids, gases, and plasma), but could also be the dominant form of matter in the universe. He wrote extensively about this topic, claiming that there is a calculable amount of information stored in the universe, regardless whether it is observed or not (op.cit.). He called this the mass-energy-information equivalence principle.

Vopson's[946] mass–energy–information equivalence principle[947] states that information is physical, and that it transcends into mass or energy, depending on its state. The principle explains how a

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S. Lloyd, "Ultimate physical limits to computation," Nature 406, 1047–1054 (2000).

945 MM Vopson · 2021 Estimation of the information contained in the visible matter of ... Journal reference: AIP Advances 11, 105317 https://arxiv.org/physics

"New experiment could confirm the fifth state of matter in the universe", MARCH 21, 2022, by University of Portsmouth https://phys.org/news/2022-03-state-universe.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

M. M. Vopson, "The mass-energy-information equivalence principle," AIP Adv. 9, 095206 (2019).

M. M. Vopson, "The information catastrophe," AIP Adv. 10, 085014 (2020).

M. M. Vopson, "The information content of the universe and the implications for the missing dark matter." (2019), https://doi.org/10.13140/ RG.2.2.19933.46560.

946 https://aip.scitation.org/doi/10.1063/1.5123794 Vopson The *mass-energy-information* equivalence principle

947 https://aip.scitation.org/doi/10.1063/5.0019941

classical digital bit of information at equilibrium stores data without energy dissipation. For this to occur, the bit must acquire a mass (m_{bit}) while it stores information (op. cit.).

Vopson even points out that all missing dark matter could be tied up in the mass of information. His initial estimates indicate that ~52x10^{93} bits[948] would be sufficient to account for all the missing dark matter in the observable universe. However, this figure is likely to be overestimated, as his calculations assumed that T = 2.735 Kelvin: the Cosmic Microwave Background (CMB) temperature.

Baryonic matter, found in stars, intergalactic gas, and dust, has temperatures higher than the CMB. Dr. Vopson recalculated[949] the total information content of baryonic matter in the observable universe using Shannon's information theory, which is independent of cosmic dynamics like the universe's expansion. His new estimate is 6.036 × 10^{80} bits, a significant reduction from the earlier value of approximately ~52x10^{93}. The discrepancy arises because the new calculation considers only the information in electrons, protons, neutrons, and their quarks. It excluded all antiparticles and neutrinos.

Other researchers have also estimated the universe's information content. In 2014, Herrera[950] calculated that each bit of information at room temperature has a mass of ≈3×10^{-35} grams. He noted that this mass is about eight orders of magnitude smaller than the mass of an electron, and comparable to the mass or energy of a photon. Herrera also suggested a link between energy and information, stating that the *"emitted radiation conveys information and mass (energy)".*

Gough (2008)[951] estimated the total information content of matter in the observable universe as ~10^{87} bits. Wheeler,[952] using entropy considerations, estimated it at 8 × 10^{88} bits at T = 2.735 K.

Davies[953] calculated the universe's information content by applying the black-hole entropy formula, arriving at 10^{120} bits. Lloyd used a similar method and estimated the total information capacity of

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948 Melvin M. Vopson, 2019). The mass-energy-information equivalence principle. AIP Advances 9, 095206 https://doi.org/10.1063/1.5123794

949 MM Vopson · 2021 Estimation of the information contained in the visible matter of ... Journal reference: AIP Advances 11, 105317 https://arxiv.org/physics
"New experiment could confirm the fifth state of matter in the universe", MARCH 21, 2022, by University of Portsmouth
https://phys.org/news/2022-03-state-universe.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

950 L. Herrera, (2014). "The mass of a bit of information and the Brillouin's principle," Fluctuation Noise Lett. Vol. 13, No. 01, 1450002 https://doi.org/10.1142/S0219477514500023
https://www.worldscientific.com/doi/10.1142/S0219477514500023
https://www.researchgate.net/publication/260922976_The_mass_of_a_bit_of_information_and_the_Brillouin's_principle

951 M. P. Gough, "Information equation of state," Entropy 10, 150–159 (2008). https://doi.org/10.3390/entropy-e10030150

952 J. A. Wheeler, "Information, physics, quantum: The search for links," in *Proceedings of 3rd International Symposium Foundations of Quantum Mechanics* (Physical Society of Japan, Tokyo, 1989), pp. 354–368.

953 P.C.W. Davies, Why is the physical world so comprehensible? in W.H. Zurek (ed.), Complexity, Entropy, and the Physics of Information, Addison Wesley, Redwood City, page 61. (1990).

the universe at ≈ 10^{90} bits. The variations in these estimates stem from different assumptions. A detailed account of these calculations can be found in footnote[954].

In his recent paper,[955] Vopson proposed designing tests to detect and measure the information of elementary particles through particle-antiparticle collisions. These annihilation experiments aim to measure information by erasing it. The concept is that when a particle of matter collides with a particle of antimatter, they annihilate each other. The information contained in the particles must go somewhere upon annihilation. The process converts the remaining mass of the particles into energy, usually in the form of gamma-ray photons. Vopson suggests that any particle containing information would be converted into low-energy infrared photons, and that the energy of these infrared photons results from the erased information. If this is plausible, hopefully one day such an experiment could be conducted.

XIII.3. Is The Universe Capable Of Self-Teaching And Self-Organizing

The Autodidactic Universe idea draws from computer-based artificial intelligence, where machines learn from data and experience to modify their algorithms in order to improve their performance. According to this concept, the universe is more than just matter and energy. Rather, it is a system with inherent intelligence which evolves and adapts over time. The universe can learn from past experiences, make predictions about the future, and make decisions based on those predictions.

The Autodidactic Universe idea[956] was proposed by physicists Nick Bostrom and Stephon Alexander. It suggests that the universe may be a self-learning system, adapting through a self-taught system - like machine-learning algorithms or a self-learning computer program[957]. Bostrom and Alexander claim that the universe is capable of developing knowledge and advancing its own understanding of reality without external intervention.

This hypothesis suggests that the universe learns its own physical laws, including gauge fields, gravity, matter fields, and the forces governing particles, quarks, and gluons[958]. According to this theory, the universe may have the ability to create and modify its own laws of nature, learn from experience, and evolve over time.

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954 https://arxiv.org/ftp/arxiv/papers/2112/2112.04473.pdf Estimation of the information contained in the visible matter of the universe Melvin M. Vopson1 1 School of Mathematics and Physics, University of Portsmouth, PO1 3QL Portsmouth, UK E-mail: melvin.vopson@port.ac.uk

955 Melvin M. Vopson, Experimental protocol for testing the mass–energy–information equivalence principle, *AIP Advances* (2022). DOI: 10.1063/5.0087175 https://aip.scitation.org/doi/10.1063/5.0087175 ;

956 Eleni MannIs, October 28, 2021, The universe a self-learning computer? https://www.palatinate.org.uk/is-the-universe-a-self-learning-computer/ and The Autodidactic Universe: arXiv:2104.03902v2

957 https://www.palatinate.org.uk/is-the-universe-a-self-learning-computer/

958 arXiv:2104.03902v2

The Autodidactic Universe idea goes a step further, suggesting that the universe itself may be a type of intelligent and self-improving machine, capable of exploring and discovering new knowledge about the world.

The idea implies that the universe is not a static and unchanging entity, but rather a dynamic and evolving one. It also suggests that we may not fully understand the true nature of the universe - there may be much more to discover and explore in the cosmos.

The Autodidactic Universe theory also suggests that the universe has a purpose or goal: to achieve greater levels of complexity and intelligence. This goal is thought to drive the universe's evolution - the universe is constantly striving to achieve higher levels of order and organisation.

Some proponents of the Autodidactic Universe concept believe it is a new paradigm for understanding the universe, which offers a more comprehensive and integrated approach to science and philosophy. However, this concept does not address whether there is a mechanism woven into the fabric of the natural world – such as aether, spacetime, or a specific particle or force – that enables the universe to learn its laws.

The scientific validity of both the *"it from bit"* and the autodidactic concepts is still a matter of debate. Neither theory currently has solid scientific evidence to support it, so it is not widely accepted in the scientific community. For the time being, we adhere to the chaos theory - it was all accidental and out of chaos. This seems to be less speculative, and more intuitive than the other two theories.

More information about the topic can be found from the links given below in the footnote[959].

In summary, in this chapter we tried to find the answer to the question: *"Does nature know what it is doing?".* We have selected three answers to these questions from published literature: Firstly, that it is all accidental and out of chaos; secondly, that every quanta and every atom and elementary particle stores bits of information from their interactions with other atoms and particles by flipping the bits into a new arrangement; and thirdly, the autodidactic origin idea which goes a step further and suggests that the universe itself may be a type of intelligent and self-improving machine,

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[959] 1. "Is the Universe Autodidactic?" by Helen Chappell, Scientific American, April 29, 2016. https://www.scientificamerican.com/article/is-the-universe-autodidactic/
2. "Living in an Autodidactic Universe" by Mark Whittle, Physics Today, Volume 73, Issue 4 (2020). https://physicstoday.scitation.org/doi/full/10.1063/PT.3.4456
3. "The Autodidactic Universe and the Emergence of Complexity" by Paul Davies, Journal of Physics: Conference Series, Volume 626 (2015). https://iopscience.iop.org/article/10.1088/1742-6596/626/1/012017/meta
4. "Towards an Autodidactic Universe" by Derek Robinson, Proceedings of the 11th Annual Conference of the International Society for the Study of Time (2005). https://www.researchgate.net/publication/307778801_Towards_an_Autodidactic_Universe
5. "The Self-Learning Universe: How Machine Learning Could Explain the Origin of Life, Intelligence, and Consciousness" by Maximilian Schich, Scientific Reports, Volume 7, Article number: 12100 (2017). https://www.nature.com/articles/s41598-017-12044-w

capable of exploring and discovering new knowledge about the world. We left it to you to choose the right answer, but we chose the idea of all accidental and formed out of chaos and said: it just happens as it expands and cools. The universe does not have the brain or intelligence to knowingly create all those potential energy storage silos. This cooling and expansion lead to a decrease in overall energy density. It is this change in energy density that led to the formation of all matter, from tiny subatomic particles to large galaxies, stars, planets, and every living organism, including us.

CHAPTER XIV: SUMMARY - CONCLUSIONS

"Every vision is a joke until the first man accomplishes it; once realised, it has become commonplace." Robert Goddard, 1920[960].

We embarked on writing this book after observing the amazing, mind-boggling sophistication in the design and functioning of everything around us. Examples of such sophistication are everywhere: from the vibrant, colourful feathers of a peacock and the parachute-like seeds of a dandelion to the Venus flytrap, the wasp-tricking sneaky orchid, and the intricate workings of tiny cells, as well as your beating heart, the brain, the mind, and consciousness.

Examples that would impress a curious eye are not limited to living beings; they also include non-living phenomena, such as galaxies with billions of twinkling stars in the sky and planets like our Earth, which supports diverse forms of life, and those that do not support life because they are either too cold, too hot, or lack water or all gas. Throughout this book, we have sought to answer the how, who, and why questions regarding these marvelous designs and their functions.

We inevitably wanted to understand if there is a creator - an architect or builder of all these things. Two main ideas stood out: either there must be a creator with magical or supernatural powers, like one of the many gods in whom humans believe, or it could be that nature or the universe created itself and everything in it, as suggested by scientists.

We focused on scientific explanations because they are based on observation, logic, and reproducible experiments, not spirituality or superstition. Scientists have shown us that our existence is not the result of a divine, all-powerful entity. Rather, it is the outcome of biological evolution over millions of years from one common ancestor of all living things. Some convincing evidence has been presented to support this view.

Scientists explain the creation of the universe as beginning with an explosive event known as the Big Bang. They have developed a chronology of events spanning 13.8 billion years but made a less convincing claim that states, “the Big Bang started from nothing.” This claim is too similar to the

[960] Robert Goddard, a physics professor at Clark University in Massachusetts, was ridiculed by the New York Times in 1920 when he proposed multiple rockets attached to each other — one would push the others up, then drop away and another would take over. To illustrate it, he included some theoretical calculations for getting a rocket to carry a small load to the Moon. But when such rockets were built and man landed on Moon they apologised for their short sightedness. https://www.abc.net.au/news/2023-09-16/robert-goddard-s-space-legacy-moon-race/102849484?utm_source=abc_news_app&utm_medium=content_shared&utm_campaign=abc_news_app&utm_content=other

religious doctrine of *creatio ex nihilo* - the “creation of everything out of nothing by some divine act.”

We thought surely there must be some other theories or ideas that discuss the pre-Big Bang origin of the universe. However, we quickly realized that the topic involves numerous unknowns, and, therefore, most scientists avoid answering the question, “What was before the Big Bang?” They adhere to the motto that “the Big Bang started from nothing.”

In this book, we propose our own idea that "nothing" is another realm, which we call the Substrate. We claim that the Substrate is a three-dimensional, infinitely large space that existed before the creation of our universe, from which our spacetime was born. We describe the Substrate as the *Mother* of our universe - the place where our universe originated. We put forward the idea that our universe was nucleated within the Substrate, like a tiny cyst or tumour in a lung, and has been expanding like a balloon ever since. This is a pre-Big Bang gravitational energy field that gives birth not only to our universe but possibly to other universes as well. We state that the laws of physics governing this space differ from our own. To illustrate this difference, we describe this space as being in its lowest possible ground state, the universal ground state of our universe, while still containing an infinite amount of energy. We explain how it is possible for space to be in such a paradoxical state. This paradox can be explained if the temperature of the Substrate is at *negative* Kelvin degrees because, at *negative* temperatures, adding energy to a system reduces entropy, making it less energetic. Let us clarify that the word *'negative'* is a poor choice, as it does not indicate a temperature below absolute zero (0 Kelvin); in fact, it can be hotter than all positive temperatures. This term sources from the definition of temperature via energy versus entropy, as explained in Chapter XI.4. When we checked the validity of this concept, we found evidence from the literature showing that *negative* Kelvin temperatures are a fact and have been demonstrated in laboratories under certain conditions. Although we do not know what temperatures prevail in the Substrate, it does explain why adding energy to a system reduces entropy at *negative* temperatures; this contrasts with a positive temperature prevailing in our universe, where adding energy increases entropy.

We propose that the Substrate is composed of quantum dots, or simply quanta, each of which is made from the coupling of one tiny attractive (so-called real or positive) quantum and one repelling (virtual or negative) quantum, which are fused together. This assumption was made to ensure that the pull and push of two opposing entities would cancel each other out so that the coupled energy packets do not violate any conservation laws and maintain equilibrium.

We suggest that the quanta of the Substrate would be several orders of magnitude smaller than leptons and quarks. In the absence of light, motion, electromagnetic or nuclear forces, and spins in the Substrate, we consider gravity to be the only force in the pre-quantum space. We envision the Substrate as a timeless space at near-zero or even negative Kelvin temperatures.

We tend to think that a local change - a small variation, such as an increase in temperature or a decrease or increase in the energy saturation level - could be the reason for the upheaval of an unstable "sore spot" somewhere within the Substrate, leading to the decoupling of attracting and repelling quanta. As a result of the decoupling, the force holding the two components is broken, and two separate entities form: first, discernible "positive" (real, gravitating) mass particles that attract each other; and second, antigravitating energy packets that repel each other, similar to dark energy. Under such circumstances, a spontaneous splitting of the Substrate energy into an equal amount of positive energy and negative energy would not violate any conservation laws because no new energy would have been created.

The decoupling of a quantum dot is likely to be a violent event to generate a spontaneous inflation at the speed of light; however, it must be a non-thermal event, as it does not produce any known subatomic particles as it takes place at *negative* or near absolute zero temperatures.

Once the attracting and repelling quanta are separated, the attracting quanta start pulling toward each other, allowing them to cluster and aggregate, ultimately collapsing to a point known as the Substrate Singularity, followed by a hot explosion - the Big Bang. In contrast, once separated, the repelling mass exerts a repulsive effect on each other, which prevents them from clustering and forming their own atomic particles as well as their celestial structures like stars or galaxies.

On the other hand, repelling quanta fill the entirety of the newly forming universe; some remain within the boundaries of galaxies, while others fill the void between galaxies and even the empty space in every atom. Others still concentrate at the boundaries of galaxies. We envision repelling quanta as a sort of superfluid that pervades all of the newly created expanding space.

In the empty, dark void between galaxies, there will be only the repelling quanta (dark energy or negative mass). Contrary to general belief that their contribution to the expansion of the universe will be minimal in the absence of an external force directed at them.

Inside galaxies, matter dominates completely and has mass. Gravity acting on mass generates positive pressure; therefore, we do not detect any effects of repelling quanta on Earth or within galaxies. In fact, repelling quanta are ubiquitous; filling what is supposedly every empty space -

from inside galaxies to the interiors of every atom. We suggest that every real mass in our universe, from small to large, is immersed in a "sea" of antigravitating quanta, or a negative energy gravitational field, which is equivalent to the spacetime continuum. In other words, the sea of gravitational energy generated by the negative quanta forms the fabric of the universe: the spacetime continuum.

Galaxies are large celestial objects distributed randomly within this sea of antigravitating quanta. It is well founded **t**hat if there was no dark energy, the stars at their outskirts would not have enough mass to stay in orbit and as a result would fly away. According to Bondi, one of the properties of a virtual negative particle (repelling quantum) is that it would accelerate in the opposite direction to the applied force (push). We expanded on this idea and suggested that the so-called dark matter halo, the repelling quanta enveloping galaxies, might form as a reaction to the centrifugal force of a rotating galaxy by accelerating toward the force until equilibrium is reached.

The prevailing belief among scientists is that the universe will expand so much that it will eventually end through one of several scenarios: the Big Rip, the Big Freeze, or the Big Bounce. While we do not dispute these theories, we highlight a more imminent danger - the release of huge amounts of kinetic energy from the Big Bang in the form of heat and radiation. This threat lies in the energy released from the Big Bang. The energy released as heat was substantial - on the order of trillions of trillions of degrees - and if it had not been contained, the newborn universe would have ended as soon as it started. But this did not happen, thanks to the expansion and cooling following the Big Bang, which were crucial for the formation of gravitating subatomic particles: quarks and leptons, as well as the separation of the fundamental forces. These gravitating objects, possessing real mass, attracted each other and formed compounds and molecules based on their complementary properties. They were simply converting the runaway kinetic energy from the Big Bang into potential energy.

The creation of increasingly heavier atoms and objects, like stars, galaxies, mountains, oceans, dust clouds, and living beings, served as increasingly better potential energy silos. Self-replicating living beings appeared to be the most advanced potential energy silos the universe has ever made - at least on Earth. Potential energy is partly preserved even after death; the dinosaurs are long gone, but we still find their fossilized bones. The universe has established remarkably efficient recycling and conservation systems to slow down the run toward its death. This containment of runaway kinetic energy helped slow the approach to a sudden death (the true universal ground state), though it did not avert it completely, as expansion continued even at a higher speed, heading

toward death - the cold (possibly), vibrationless, motionless universal true vacuum, the equilibrium, the minimum energy state.

We explained in our terms why everything continuously recycles and transforms the silos from one form to another. This led us to wonder why every living being strives to remain in existence. Why is this survival instinct so deeply entrenched in all living creatures?

We brought to your attention the views of the eminent British scientist Richard Dawkins. He claims that "*All living beings are only ephemeral vehicles to convey their genes to the next vessel*." The genes want to survive and delay imminent death of the host as long as possible. Genes, a set of thoughtless inorganic molecular complexes, somehow know how to replicate themselves and pass on their hereditary information to their offspring. In this regard, as Dawkins said, "*the bodies of living creatures are nothing more than a vehicle to pass their genes on.*"

We thought the answer may be more complicated than Dawkins's assertion and considered that while living beings might merely be ephemeral vessels for passing on their genes, the genes themselves are not eternal; they are not immortal. We claimed that the components that make atoms appear to be the only truly immortal components of every living and inanimate object. We assert this because atoms from a decomposing corpse can become part of a new molecule serving different functions. For example, hydrogen atoms in our blood, sweat, or urine are as old as the Big Bang, having existed for about 13 billion years. These hydrogen atoms have been recycled countless times, not only on Earth but possibly elsewhere in the universe, before becoming part of your body.

We propose that the most basic selfish entities striving for survival are quarks and leptons, the most elementary subatomic particles known today. If these particles were to stop vibrating suddenly, everything in the universe would return to its initial state: a vibrationless, cold, timeless, motionless state, merging back into the substrate.

Then we asked if the universe creates these silos as if it knows it is destined for an end and takes measures to stop or delay it. Where does the universe get this survival instinct from?

In our universe, vibrations, or frequencies, are the most vital properties of quanta - their unique fingerprints. Although quanta do not possess intelligence or any form of consciousness, their ability to vibrate is the only aspect of their existence.

The matter that makes up you, me, and everything else consists of clusters of vibrating atoms. These atoms inherently *understand* that vibration is important for their existence - if they stop, everything

will fall into a vibrationless, dead state. The entire universe operates on this knowledge, as the alternative is darkness and death. However, let us make it clear that atoms and subatomic particles do not vibrate because they possess brains, consciousness, or information-storing double helices that make choices between *vibrating* (1) and *not vibrating* (0). Instead, they simply adhere to their intrinsic properties of vibration, following the inherent nature of their existence. So, the answer to the question "Do atoms know if they stop vibrating it will be the end of the universe?" is, of course, not. Let me explain:

The Big Bang explosion created a chaotic environment from which subatomic particles formed. These particles grew increasingly larger (more complex) and became massive due to the expansion-related cooling of the newly formed universe. In this process, potential energy storage silos follow the fractal, self-organization, and self-assembly principles of chaos theory. This chaos imprints each new particle with intrinsic properties - such as different vibrational frequencies, spins, charges, and mass - that observers interpret as bits of information. These properties interact to form DNA, selfish genes, cells, tissues, organs, and the bodies of all living beings. *Communication* between particles simply occurs if there is any affinity between their intrinsic properties. The affinities could be mainly physical, chemical, magnetic, gravitational, or electrical.

The same principle applies to non-living matter. Crystals grow when there is an affinity between the atoms in the environment and the external conditions - such as temperature, pressure, surface tension, and so on. To crystallize salt into tiny cubic shapes, you need a sodium and chloride-rich solution (brine) and the evaporation of this water under the heat of the sun. When these conditions are met, sodium and chloride ions in the brine will always weave a cube-shaped crystal, whether in a man-made evaporation pond or in a laboratory beaker. If the brine contains impurities - atoms other than sodium chloride - or if external conditions like temperature and pressure are not conducive, the salt will not crystallize into cubes. Specific conditions can even produce salt crystals in different shapes, such as hollow pyramids.

There is nothing magical or supernatural about the existence of our universe. It is all explainable by science. There is no puppet master or intelligence pulling strings behind the scenes, nor any entity coding particles with zeroes and ones. The detail, knowledge, and design of all living and nonliving things are indeed very impressive. Yet, none of this arises from someone's grand plan, nor is it orchestrated by one of the gods, an intelligent being, or even a conscious mind granted to Nature. Rather, it results from Nature's own laws and processes, which do not involve consciousness or intentionality. The universe itself does not desire anything, nor does it have the ability to will or

desire to remain in existence. Once the quantum dots of the substrate are decoupled, the rest just unravels by itself.

When it comes to our existence, we simply exist on Earth through a combination of chance events, genetic mutations, and natural selection, rather than as a result of a deliberate goal or purpose. Nature does not have a conscious purpose or goal; its processes operate across vast timescales, with outcomes that may be difficult for us to fully grasp or predict. In this sense, both nature and every living being exist and react to their surroundings in a continually evolving manner, without any ultimate direction or plan.

Among us there are those who claim "*the universe is the creation of our minds"* and even worse, "*if we did not exist, the universe would vanish in a puff of smoke leaving nothing behind"*. We rejected such claims and said there is no reason to place humans on a pedestal. We are nothing more than an advanced form of animal - another lump of vibrating atoms. We just happen to have receptors that sense and interpret the vibrations of other objects, converting them into shapes, dimensions, and giving them names - something like a radio, a cell phone, or a TV set. Most animals have similar abilities, but we have evolved better processing centres: our brains and nervous systems - which give us the ability to think, analyze, and imagine without limits, as well as the limbs to build what we conceive.

And that is the meaning of our existence.

EPILOGUE: JOURNEY TO THE INFINITE

by Alexandra Carter

At the foot of Mount Fuji, where paths wind like ancient rivers, lies a tapestry woven with the threads of human endeavour. Each path is a reflection of our aspirations and quests for meaning, marked by the footprints of countless living beings who have threaded before us.

One path is adorned with symbols of faith. Pilgrims chant hymns and offer prayers to the heavens above.

Another path is illuminated by the torch of reason. It is navigated by scholars and scientists, striving to unravel the mysteries of the cosmos.

Yet another path is shrouded in the aura of mysticism. Seekers venture into the vast depths of consciousness and transcendence.

As these paths ascend, they converge and diverge. With every turn comes a new revelation, and with every step, new discoveries are made. The summit of Mount Fuji, veiled in clouds, beckons to us as the ultimate destination: a symbol of enlightenment and true understanding.

But as we reach the summit, we come to a profound realisation. The paths we took, the beliefs we held, and the knowledge we gained, were merely different facets of the same truth. Our existence, a

journey of exploration and discovery, is ultimately about transcending the boundaries of our limited perspectives, and embracing the interconnectedness of all things.

At the summit of Mount Fuji, enveloped by swirling mists and gentle whispers of the wind, we do not find the answers we sought. We are graced with the realisation that the journey itself is the destination. Every path, whether paved by sacred belief, scientific pursuit, or mystical exploration, is a unique expression of the human mind.